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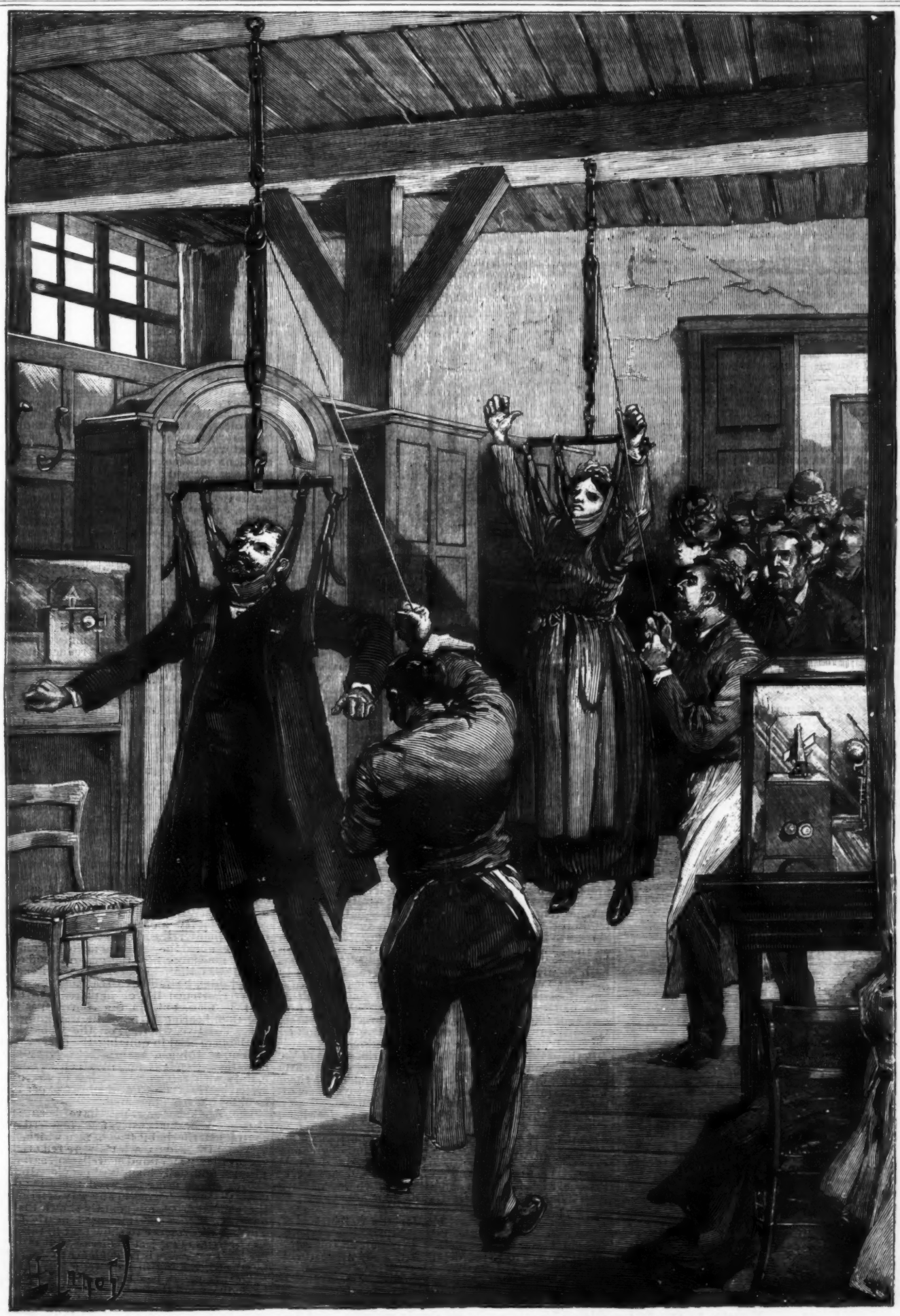
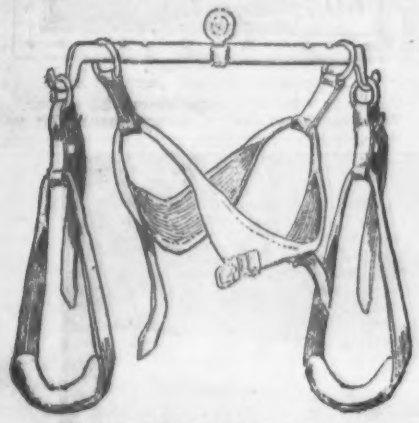


NEW TREATMENT OF LOCOMOTOR ATAXIA BY SUSPENSION.

NEW TREATMENT OF ATAXIA.

Although, to use Voltaire's expression, medicine too long remained "the art of putting drugs which we do not know about into a body which we know still less about," we shall not reproach contemporaneous science with having persevered in following this antique course.

To-day, medicine is, before all else, hygienic, hydro-



SUSPENSION APPARATUS.

pathic, electric, pneumatic, hypnotic, magnetic, etc., and hardly pharmaceutic any longer. The remedy is taking its departure, driven out by the process. Yesterday, we recommended consumptives to keep to their rooms; now we send them out to take a walk. We have been treating those afflicted with nervous troubles with valerian and bromide; hereafter, we are going to hang them! Hang them! Is it possible? That is about it; only we shall use the word *suspend*, so as not to frighten them too much. Still, future usage of it under such circumstances will be wholly improper, for it is quite six months since we have been *hanging* them. After all, what is there surprising in it, since the method succeeds? It is giving proofs of its efficacy every day. Everybody is already talking about it. To-morrow it will be the rage, and next year we shall all be hanging ourselves.

At Paris, up to the present, it is at the Salpetriere, and in Prof. Charcot's interesting service, that suspension is especially under experiment; but all the merit of the invention appears to be due to Dr. Motchoukowsky, of Odessa, who, as long ago as 1883, published a note upon the good effects of this singular process in the treatment of locomotor ataxia and of some other diseases of the nervous system.

The lamentable state usually exhibited by subjects afflicted with that serious affection of the spinal cord, chronic *myelitis* or *tabes dorsalis*, which manifests itself, after very acute pain in the limbs, by paralytic disorders, is well known. It is impossible for these unfortunates, who are unable to stand erect upon their legs, to take a step without the risk of falling. At every instant, if they try to walk, they are seen to stumble, stagger, and put their feet (which do not feel the ground) one before the other by jerks. In darkness, they cannot budge without getting a fall, and if they close their eyes, they believe themselves to be truly suspended in the air. May it not have been this odd sensation, which is more or less common to all tabetics, that accidentally suggested to Dr. Motchoukowsky the idea of suspending them for their good? "*Similia similibus curantur*," say the homeopaths. But such was probably not the genesis of the invention. In fact, American specialists antedated the Russian physician in suspending ataxic patients in order to inclose them in a plaster jacket designed to keep up this forced extension for some time. It was after practicing this operation a number of times that Dr. Motchoukowsky thought that he could attribute its results, not to the plaster jacket, but to the suspension solely. From this moment he suspended all his patients, and the novelty of the method contributed none the less than did its advantages to give it a reputation.

Much in practice now in several large cities of Europe (the reason why will presently be seen), the method of suspension has been but very recently revealed to French physicians by Dr. Raymond, on his return from

POSITION OF THE HEAD IN THE APPARATUS.

a medical mission to Russia, where he was guided by Dr. Onanoff, a pupil of the Salpetriere.

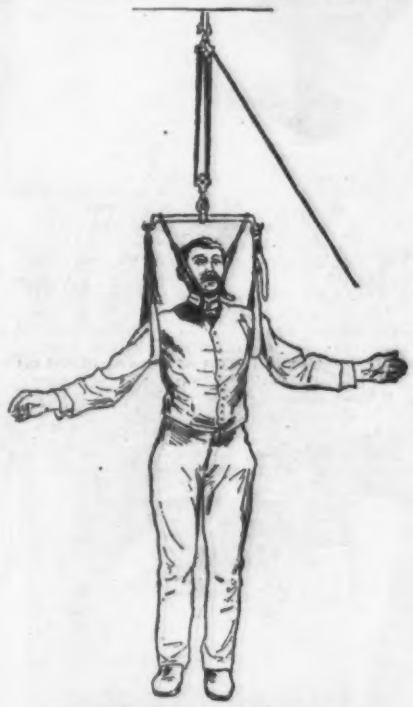
In order to judge scientifically of the value of the method, Prof. Charcot has been pleased to allow his chief of staff, Mr. Gilles de la Tourette, to experiment upon it; and that is how it is that numerous ataxics, attracted by the great renown of the learned physician, are at present going two or three times a week to him to ask to be hoisted high and dry by the rope of salvation.

But let not the poor lame imagine that if a person goes to the hospital upon crutches he will return as if from the fountain of youth. "As soon as taken, so soon hanged," is a dictum that has been current for a long time; but, unfortunately, we do not as yet say: "As soon as hanged, so soon cured."

Although the suspension apparatus in nowise recalls the gallows, and the treatment in itself is entirely inoffensive when it is properly applied, it is, nevertheless, not a genuine pleasure to feel one's self lifted by the head to a few inches above the floor. It is necessary to get used to it, in order to acquire the habit and to learn how to remain gradually from half a minute to four minutes in the air.

The operation is practiced at the Salpetriere with every desirable prudence, by means of the Motchoukowsky apparatus, which is very accurately represented herewith from original sketches that Dr. Paul Richer has been good enough to put at our disposal. It consists essentially of a stiff bar, in every respect like a scale beam, and supporting, through its terminal hooks, a leather strap. After the patient has put his arms, up to the armpits, through two padded slings supported by the straps, his head is imprisoned in a double sling which is attached above to the transverse bar and serves as a strong point of support beneath to the nape of the neck and the chin. Thus harnessed, the patient has nothing further to do but to be hoisted. A pull upon a rope running over a pulley suspended from the ceiling and supporting the apparatus, and the thing is done.

Not long ago, in a very remarkable lesson, Prof. Charcot made known the results of suspension upon the ataxics treated at the Salpetriere. They are encouraging enough to make the experimentation worth being continued, despite that, out of eighteen tabetics, more or less improved, none, truly speaking, has been radically cured. But it is something at least for the afflicted to have succeeded in gradually holding them-



SUSPENSION OF A PATIENT.

selves erect, in making a few steps, and walking without aid, when it could not be done before, and when the classic treatment by application of fire along the spine was powerless to produce these same improvements. Between being hanged or burned, ataxic patients will, therefore, probably prefer hereafter efficacious suspension to ineffectual cauterization.

What renders the new method particularly interesting in the eyes of the general public is that it does not appear to be useful solely to the victims of ataxia. In all times, as we know, true hanging, that in which a person is "hanged by the neck until he is dead," has been rightly regarded as a relatively agreeable punishment, and only cruel in that it too quickly destroys sensations that have been awakened for a moment. Now hanging attenuated by the Motchoukowsky process undeniably possesses, although to a less degree, and without strangling a man, the stimulating and regenerating properties of complete hanging.

Perhaps we have here the least serious side of the question, but to a wholly different category of infirm persons it opens up such horizons that many of them will certainly risk wryneck in order to recover their extinct animation and lost energy in suspension.

Besides, there is no doubt that at Paris, as elsewhere, some large sanitary establishment—hydropathic or bathing—will soon give its most ailing patrons an opportunity of profiting by this peculiar kind of gymnastics. High livers out of wind, prematurely old men and *blasé* youths; it is by multitudes and legions that it would be necessary to name those sad victims of Paris high living that will hereafter be amenable to suspension.

What a rich clientage, too, for the Salpetriere if, among its acknowledged tabetic and ataxic patients, the old hospital were pleased to admit all this somewhat mixed crowd of debilitated and neurasthenic persons!

But poverty and disease alone have an entrance to these hospitable clinics, in which, in helping the unfortunate, only the higher interests of science are considered. So those who are simply whimsical and wish to experiment with the Motchoukowsky process merely from a physiological standpoint will do well for the present to go somewhere else to get hanged!—*L'Illustration.*

ON THE USE OF TOBACCO.

By Francke H. Bosworth, M.D., New York.

In one of Columbus' earlier voyages of discovery his men, returning from the exploration of one of the smaller West India Islands, reported that they had seen the natives holding firebrands in their mouths, the smoke of which was permitted to escape through the mouth, nose, and ears. A closer inspection discovered their mistake, and for the first time made Europeans acquainted with the pleasures and delights of the use of tobacco. Its adoption and introduction among the people at home followed, and but a few years elapsed before its use became common among all civilized nations. Like all new ideas, its introduction met with opposition, and its use was interdicted by law, and forbidden by papal anathemas and clerical exhortation. Royal edicts were promulgated against it, and numberless tracts published setting forth its dangers; James I., among others, publishing his well-known tract setting forth the evils of the use of the "pernicious weed." His teaching has been forgotten, but it is interesting to record that the name which he gave it survives to this day, only we call it the "fragrant" weed, and not the "pernicious weed." Notwithstanding all this opposition the use of tobacco has increased and extended, until to-day it is probably used by every people on the face of the globe, constituting the one single universal article of commerce, in that it not only figures prominently in the commercial statistics of every civilized nation of the world, but is sold to, or cultivated by, all peoples, whether civilized or uncivilized. It is probably a well authenticated fact that the aborigines of America were the one people on the face of the globe who had not discovered a method of preparing an intoxicating beverage, and who were not addicted to the use of alcohol. It is a somewhat curious fact, then, that the most notable gift which civilized Europe received from America was tobacco, while its most notable gift in exchange was alcohol. The commentary is scarcely necessary that it was not the civilized world that suffered by the bargain. The crusade against tobacco which was inaugurated upon its first introduction to civilization continues to the present day, and it becomes a matter of some interest to inquire, in all candor, how far the charges made against it are to be accepted. Burton, who was by far the best read man, and one of the shrewdest, of his day, writing three hundred years ago in the "Anatomy of Melancholy," sums up in his quaint way as follows: "Tobacco—divine, rare, superexcellent tobacco, which goes far beyond all their panaceas, potable gold, and philosopher's stones. A sovereign remedy to all diseases. A good vomit, I confess, a virtuous herb if it be well qualified, opportunely taken, and medicinally used, but as it is commonly abused by most men, which take it as tinkers do ale, 'tis a plague, a mischief, a violent purger of goods, lands, health. Hellish, devilish, and damned tobacco, the ruin and overthrow of body and soul."

Making all allowances for his exaggerations and pessimistic habit of mind, is there not something of suggestion in this quotation, and are we not in some danger of falling into the routine habit of condemning the use of tobacco and ignoring the difference between its use and abuse? Carlyle, in his "Reminiscences," tells how he once rode sixty miles to Edinburgh "to consult a doctor, having at last reduced my complexities to a single question: Is this disease curable by medicine? or is it chronic, incurable except by regimen, if even so? This question I earnestly put; got response: 'It is all tobacco, sir. Give up tobacco.' Gave it instantly and strictly up. Found, after long months, that I might as well have ridden sixty miles in the opposite direction and poured my sorrows into the long, hairy ear of the first jackass I came upon, as into this select medical man's, whose name I will not mention." Carlyle evidently consulted a more devoted disiciple of Father Trask than of Æsculapius.

A few days ago I noticed, in one of our daily papers, a certain action taken by a prominent religious body in one of our Western States which was something as follows: "Whereas, the use of tobacco in any shape or form is a filthy, pernicious, and degrading habit, imperiling the health of the body and the welfare of the soul alike, leading to a laxity in living which is the sure road to intemperance and all vice," etc., etc.: "Therefore, it is resolved that this conference will not grant ordination or license to preach to any candidate who is a victim to this debasing habit." In the London *Lancet* of a few months ago I recall an opinion which it was almost refreshing to read, for the mere courage which enabled the writer to make so bold an assertion. I only remember now the general tend of the article, which was that, as far as the writer's observation served him, he failed to see that the use of tobacco either shortened life or impaired the health of the average man, but, on the contrary, it was an open question, bearing in mind its well known action as a nerve sedative, whether, on the whole, its use might not be beneficial in quieting the overwrought nervous system, soothing a brain overtaxed by the cares and anxieties attendant upon an active, busy life. It is mainly with reference to a few of the questions suggested by the above that the brief paper I have to offer to-night has been prepared.

The Anglo-Saxon races have been smoking and chewing now for nearly four hundred years. They contracted the habit from a race which, as far as history and tradition teach us, were remarkable for their vigor of body and mind as well, and, as far as we know, were an unusually long-lived people. In the time that we have been using the weed there is no evidence to show that the race has in any way deteriorated, but, on the contrary, it is abundantly shown that the average duration of life has increased nearly fifty per cent. There is no evidence to show that in this time the race has been more subject to disease, but rather that they are less so. There is no evidence to show that the race has lost anything in its intellectual activity, but, on the contrary, it has been a time of most marvelous fecundity in all that is great in literature. Let us look more especially at the specific action of tobacco. It is used in smoking, chewing, in snuff, and in dipping. As far as its specific action is concerned, we are only

interested in the two methods of its use—in smoking and chewing. The usual analysis of tobacco now accepted is that of Posselt and Reinmann, which is as follows:

Analysis of the Leaf.

Nicotine	0·060
Volatile oil	0·010
Bitter extractive matter	2·870
Gum and malate of lime	1·740
Chlorophyl	0·267
Albumen and gluten	1·308
Malic acid	0·510
Salts of pot. cin. and ammonia	0·734
Silica	0·088
Water	88·280
	100·00

Leaving out from this analysis the volatile oil, extractive matter, albumen, gluten, and chlorophyl, and negative and inert matter, and we have left a substance containing one part of nicotine, 4 parts of salts of lime, ammonia, etc., with 88 parts of water in 100. It is interesting to note, in this connection, that the percentage of nicotine in various kinds of tobacco varies, and that Havana tobacco contains but two per cent. of this poisonous element, while Virginia tobacco contains about seven per cent., according to some analyses. The moral of this is that we should always smoke the choicest brands of Havana cigars. In smoking, the ammonia salt may become the source of considerable discomfort in the burning and smarting tongue which results from excessive and continuous practice of the habit; of course, in chewing this action is not noticeable.

We thus are reduced to the action of nicotine for the possible deleterious influence of the plant. This element, as before stated, is present in varying proportions in the tobacco leaf; according to some writers, from one to seven per cent. It is a clear and colorless fluid, highly volatile, and of an extremely pungent, disagreeable odor and strong, burning taste. It is rapidly absorbed into the fluids of the body, and is one of the most deadly poisons known. It is rendered volatile by burning the leaf, and is present in the smoke of the tobacco. It is generally accepted that the volatilized nicotine in the tobacco smoke is more actively absorbed than is the case when the leaf is chewed, but in either case the nicotine absorption is the essential element in the production of all of the evils which can be charged to the habit.

Nicotine acts on the heart, nervous system, stomach, and upper air passages. The prominent symptoms which may be caused by nicotine, with reference to the heart, are intermission and palpitation; that is, it produces certain functional disturbances of the heart which, for the time, may be the source of more or less discomfort to the patient; but the important point is, does this condition ever lead to one of organic lesion?

I find but one writer bold enough to say that this occurs, and he only hazards the opinion (Dr. Kennedy, of Dublin) that the functional disorder may in cases eventually lead to the development of fatty changes in the muscular structure of the heart. On the other hand, there is abundant evidence to show that this is an extremely rare event. Few of us but have met with what we call a smoker's heart, one characterized prominently by the intermittent beat with some little irregularity of action and with which there may be the clinical history of occasional attacks of moderate palpitation brought on by overexertion. We keep these cases under notice, it may be for years, and we rarely, if ever, discover anything that we can call an unfavorable progress, the development of any new symptom or any evidence of weakness of the muscular structure of the heart. I confess that this is not easily to be explained. I am disposed to regard the term functional disorder as merely a cloak to conceal our ignorance of the real pathological condition, and believe that there is really a structural change of some kind which escapes our present methods of exploration, and while such imperfection exists in our means of physical diagnosis, we must continue to use the term functional disease. Still, in the case in point, whatever be the cause or explanation, we have a purely functional derangement which may exist for months or years without the occurrence of any grave or serious complication to cause apprehension.

The true explanation of the action of nicotine on the heart is probably to be found in its action on the general nervous system, and especially on the pneumogastric nerve. In acute nicotine poisoning, death has been known to take place in thirty seconds. This can only be explained by its action on the nervous system. Of course, the prominent symptoms of acute poisoning are on the circulatory and respiratory movements. It arrests respiration or markedly interferes with it, and if sufficient of the drug has been given it arrests the heart's action, producing almost instant death. We may, of course, say this is due to its immediate action on the medulla, or to its action on the pneumogastric nerve. Certainly, there is abundant clinical evidence to show an especial affinity of the drug for this nerve, whether in cases of mild or severe poisoning, as in acute or chronic cases. We may, then, sum up its action on the nervous system in producing disturbance of vision, giddiness, muscular tremors with exhaustion, sleeplessness, and depression of spirits. In addition to these, the irregularity of the heart's action may be classed as a nerve symptom, dependent on the impairment of control which the pneumogastric nerve exercises over it.

Another organ prominently affected by the tobacco habit is the stomach, giving rise to a gastric catarrh, with its usual train of symptoms, gastralgia, acidity, nausea, anorexia, etc., and which it is, of course, unnecessary to describe. The idea that this is due to the local irritant action of the nicotine or of the saline constituents of the tobacco is not to be entertained. For although, occasionally, we meet with a tobacco chewer who swallows the saliva impregnated with the tobacco juice, he possesses happily a very rare and unusual organization who can do this with impunity. The nicotine action, then, on the stomach must also be explained by its paretic action on the pneumogastric nerve. In this case we have to do with a secreting organ whose healthy functional activity depends largely on the nerve force supplied by this nerve. If now the nerve is under the influence of this powerful narcotic, the organ when called upon for the performance of its normal digestive function is found unequal to the task, and the ingesta act as a local irritant, with the result of producing a local catarrh, and each subsequent demand upon it only serves to aggravate the existing condition.

Coming, now, to the upper air passages, we find here a portion of the body which is not a glandular structure or a secreting organ *per se*, and hence one which is not liable to such impairment or perversion of function as may react in any way on the general system. It is merely a passage lined with mucous membrane, through which the inspired air carries oxygen to the air cells. Now, the use of tobacco may affect this either by direct contact or it may affect it indirectly through the effect of the nicotine on the general system. Its action through the general system can be but limited, as its effect here would be simply in diminishing secretion. We must look, therefore, for its injurious effect upon the direct contact of the smoke with the mucous membrane. Now, in those in the habit of smoking, the fumes of the tobacco come in contact with the upper air passages ordinarily in but a limited extent. In fact, of two persons in a room whose atmosphere is surcharged with tobacco smoke, one smoking and the other not accustomed to the habit, it is the non-smoker who will suffer. Furthermore, if we examine the physical characters of tobacco smoke more carefully, we find its analysis is as follows: Nicotianin, carbonate of ammonia, acetate of ammonia, empyreumatic oil, carbonaceous matter, moisture, and several juices.

Passing over these latter as merely the result of the destruction of the woody fiber, we have again the salts of ammonia and the nicotine comprising the essential elements of the tobacco smoke. So that, whether smoked or chewed, we find the active elements of possible influence of the plant in the nicotine and the saline constituents. The saline elements need but a passing word. They are in a high state of solution and their action is but feeble. Absorbed by the mucous membrane, their action is nothing. Their local action on the mucous membrane of the mouth and throat is merely as a feeble stimulant and irritant. If their action be long continued, this irritation may become quite prominent. This we have all noticed who have been addicted to something more than moderate smoking.

It is a fair inference, I think, then, that the use of tobacco, in its influence on the respiratory tract, does not directly produce the morbid condition which it is usual to charge upon it by direct action, but that it is only through the indirect influence of the nicotine absorption through the general nervous system. Now, the evidences of chronic nicotine poisoning are well known and easily recognized by the muscular tremor or unsteady hand, the dull headache, the retarded or irregular heart action, the sleeplessness, and other symptoms; and unless we have some evidence, as shown by some of these symptoms in persons addicted to smoking or chewing, of this chronic poisoning, I do not think that we are justified in attributing the existence of a pharyngeal or nasal catarrh to the use of tobacco, although undoubtedly, in many cases, an existing catarrhal condition of the fauces may be aggravated by the use of tobacco, its action being possibly the slightly irritating effect of the volatilized saline constituents of the smoke and possibly the empyreumatic oils, but mainly, I take it, through the constitutional effect of the drug as acting upon the secretions through the nerves which regulate this function.

While, therefore, by no means advocating the use of tobacco, the point which I desire to make is: Are we not often liable to fall into a mistake in universally condemning its use without sufficient grounds, and is it not better when our advice, as physicians, is asked, in this respect, to base our answers entirely on the evidences of the effect of the drug upon each individual patient and, furthermore, to recognize the fact that this effect is shown by well marked and easily recognized subjective symptoms? I have frequently, when asked this question, "Does smoking hurt me?" frankly said to my patients, "You know better than I do; no man uses tobacco to his harm without being fully conscious of it."

As regards its effect on the diseases of the upper air passages, in a practice of twenty years largely devoted to treatment of these affections, I recall but exceedingly few cases wherein I have found it necessary to interdict the use of tobacco as injuriously affecting in any way these passages, or as interfering with the success of treatment.

The object of my paper, then, is not a plea for the use of tobacco, but simply to suggest whether we had not best abandon the idea that it is a drug whose use is pernicious in every way to body, mind and morals, and rather to take the view that it is one of God's good gifts to man; a "virtuous herb, divine, rare, superexcellent tobacco" when properly used, but when taken "as tinkers do ale, 'tis hellish, devilish, and damned tobacco."—*Medical Record.*

REMOVAL OF TATTOO MARKS.

NEARLY every year we have one or more letters of inquiry as to the means for removing tattoo marks, and we have been obliged to reply that, practically, it is not possible. Dr. G. Variot, of the Paris Biological Society, has however lately proposed a process which he declares to be invariably successful in removing blue and red tattoo marks. As the doctor is attached to the central infirmary of the Paris prisons, he has undoubtedly abundant opportunities for experimenting, and should be able to speak intelligently. Dr. Variot operates as follows:

The tattooed parts are first wetted with a concentrated solution of tannin, and then, with a set of tattooing needles, the skin is punctured all over the colored portions to the depth usually adopted by professional tattooers. All the parts tattooed with tannin are then rubbed over with a crayon of nitrate of silver until the needle pricks have turned black. Excess of liquid now being wiped off, matters are allowed to take their own course. The whole surface treated will soon turn black. The pain, which is quite moderate during the operation, continues to be slight for the first two days, and is attended with some local inflammation. After the third or fourth day no pain is felt, and, excepting for large marks, no dressing will be necessary. After fourteen or eighteen days the eschar will fall off, and leave, instead of the tattoo marks, a reddish, superficial cicatrix, which will gradually turn pale, and after two months will almost disappear.

TRAUMATIC EPILEPSY SUCCESSFULLY TREATED BY TREPHINING.

By F. A. SOUTHAM, M.B. Oxon., F.R.C.S., Assistant Surgeon to the Manchester Royal Infirmary and Surgeon to the Clinical Hospital for Women and Children.

WILLIAM F——, aged thirty-two, telegraphist, came under my care as an out patient at the Manchester Royal Infirmary in August, 1887, with the following history. In December, 1886, having previously enjoyed good health, he fell from a height of sixteen feet and sustained an injury to the head in the left temporal region, apparently a severe scalp wound without any fracture. He was removed in an unconscious condition to a local hospital, where he remained for about three weeks.

At the end of this period he was discharged, having quite recovered from the effects of the accident. Shortly afterward he began to suffer from attacks of a somewhat peculiar nature. Without any warning, he would suddenly be seized with twitchings limited to the muscles of the right side of the face, and almost simultaneously he would become dizzy and fall to the ground in a state of complete unconsciousness, remaining in this condition for a varying period, often for several hours. In the intervals there was no evidence of paresis in the muscles of the face or any other part of the body; speech was not affected, and there was no loss of sensation or impairment of any of the special senses.

The attacks recurred at irregular intervals, sometimes as many as six daily, sometimes three or four a week; occasionally a week, but rarely longer, would pass without one. He again sought treatment at the same hospital, and underwent two operations, which from his description consisted in liberating the scar on the scalp by dissecting it up from the bone beneath; each operation was followed by a temporary cessation of the fits, which, however, soon recurred.

The man was suffering from a continuance of the same symptoms, which completely incapacitated him from following his occupation, when he came under my observation. On examination, a well-marked adherent cicatrix about an inch in length was found in the left temporal region; no depression could be felt in the bone beneath indicating that there had been a fracture. He was put on a course of bromide and iodide of potassium for three weeks, but without any relief to the symptoms, the fits recurring as before. My colleague, Dr. Ross, then examined the patient with me, and as the case appeared to be one of traumatic epilepsy, due to irritation of the brain at the seat of injury, he recommended that the skull should be trephined at this spot. On Sept. 7, 1887, the operation of trephining was performed with careful antiseptic precautions. The old scar was dissected up from the bone beneath, and, the pericranium having been reflected, a crown of bone the size of a shilling was removed at a point two inches and a half above and one inch behind the external angular process of the frontal bone. The piece of bone removed did not present any evidence of fracture, but was irregularly thickened and sclerosed, the diploe having disappeared and been replaced by dense, compact, osseous tissue; its outer surface was roughened, and at one point on its under surface there was a bossy elevation, a quarter of an inch in diameter, whiter in color and of denser consistence than the surrounding bone.

The exposed portion of the dura mater was rough and unduly adherent to the bone; otherwise it presented a healthy appearance; as it did not bulge into the trephine opening, and there were no evidences of intracranial tension, it was not incised, for it was thought that the irritation caused by the pressure of the thickened bone was sufficient to account for the symptoms. The wound was then closed, the peri-cranium being brought together with catgut and the scalp with silver sutures, and a small drainage tube inserted.

Healing rapidly occurred, with very little suppuration, the temperature never rising above 99°. On the eleventh day the patient was sitting up in the ward, and on the twenty-third day he left the hospital, there having been no return of the fits since the operation. About a fortnight later, however, they began to recur at irregular intervals, but in a very much milder form than previously, consisting merely of attacks of giddiness accompanied by pain in the head, but without any loss of consciousness, and, except on one occasion, without any twitching of the muscles of the face. These attacks gradually became slighter and less frequent, and since January, 1888, he has been entirely free from them. In the following April he was able to resume his occupation as telegraphist on the railway, and at the present time is in the enjoyment of perfect health, being as well as he was previously to the accident. The seat of the operation is now indicated by a depressed scar. There is no tenderness on pressure over it, and no pulsation can be detected.

Remarks.—As regards the explanation of the epileptic attacks, which were the secondary result of the injury to the head, it is probable that at the time of the accident, in addition to the wound of the scalp, more or less bruising or contusion of the bone beneath was also produced. This was followed by inflammatory changes in the bone, and probably also by some inflammation of the subjacent dura mater, in consequence of which the bone became thickened and sclerosed and unduly adherent to the membrane beneath. The result was that pressure was produced on the cortex of the brain, and this, acting as a source of irritation, gave rise to the fits from which the patient suffered.

It is interesting to note that the fits commenced with twitchings of the facial muscles on the opposite side to that which was the seat of injury.

According to the observations of different experimenters, the center which presides over the movements of the face is situated in the lower and middle part of the ascending frontal, the lower end of the ascending parietal, and the posterior end of the middle frontal convolutions. Now, the portion of bone removed with the trephine would overlie the posterior end of the middle frontal convolution, and the successful result of the operation is doubtless to be explained by the fact that the pressure upon the surface of the brain at this

spot, which acted as a source of irritation, was relieved by the removal of the thickened bone. As the patient has now been free from any recurrence of the fits for a year, the cure may probably be regarded as complete and permanent.—*Lancet.*

COMPOSITE GEARING.

INVOLUTE AND EPICYCLOIDAL SYSTEMS COMBINED.

By Prof. C. W. MACCORD, Sc.D.

THE accompanying diagram, Fig. 1, shows the construction of the teeth of a wheel and pinion in which the involute and the epicycloidal systems are combined in such a way as to secure advantages which could not, under the given conditions, be realized by the use of either system alone.

These teeth were designed for the special case of a train of clockwork in which the chief desideratum was a perfectly smooth action and uniform transmission of motion, with as little frictional resistance as might be; the pinions, of twelve teeth each, being driven by the wheels, which have from ninety to one hundred and forty-four teeth.

The involute system is peculiarly well adapted for work of this description, on account of the constant obliquity of the line of action, which gives an unvarying component of side pressure tending to take up the necessary "side shake" of the pivots in their bearings; but this obliquity must not be too great. And the amount of obliquity necessary depends upon two things—the relative diameters of the driver and follower and the magnitude of the arc of recess. In view of the well established fact that the friction after passing the line of centers is less injurious in its effects than that before reaching that line, it was considered desirable in the present case to make the arc of recess equal to the pitch, and the arc of approach one-half as great.

Now, these conditions *could* be satisfied by using purely involute teeth, since a pinion of 12 leaves can be driven by a wheel of only 59 teeth, with the above mentioned arc of recess; but that is an exact limiting case, the teeth of the wheel being pointed; and the requisite obliquity is 27° 38′ 12″.

To be sure, since the proposed wheels have more than 59 teeth, there would be a slight thickness at the top of the tooth; but the curvature of the involute does not diminish very rapidly as the number of teeth is increased; and even with an obliquity of 30° and an arc of recess equal to only three-fourths of the pitch, the wheel of 144 teeth presents the appearance shown in Fig. 2. The thickness of the tooth at the top is none too great for practical purposes, but the obliquity certainly is, and yet the receding action is much less than is wanted.

On the other hand, although the desired proportion between the arcs of approach and recess might readily be attained by using epicycloidal teeth, there is this objection to their use in the present case: that at the instant of passing the line of centers the obliquity of the line of action becomes *nil;* so that the side component of pressure vanishes. In the event, then, that, owing to any inaccuracy in spacing or cutting, the next pair of teeth had not by that time come into action, a slight play of the pivot in its bearing might result, thus interfering with the perfect smoothness of the action.

In these circumstances the following course was adopted in the construction illustrated in Fig. 1.

Draw through P the common point of the pitch circles, the line of action with an obliquity of 15°, and let fall upon it perpendiculars from the centers of the wheel and the pinion, thus determining in the usual way the radii of the base circles; then the outer part of the pinion tooth, and the inner part of the wheel tooth, will be involutes of these circles. The involute of the larger circle cannot extend above the point A, which is the root of the conjugate involute of the smaller circle. But, describing a circle upon P C as a diameter, its circumference will pass through A; and by rolling this circle upon the pitch circle of the wheel, an epicycloidal extension of the wheel tooth is generated, which by construction is tangent to the lower or involute portion, and will work correctly with the radial line A C, which is the hypocycloid traced by rolling the same circle within the smaller pitch circle. Continuing this epicycloid to the height required to secure the assigned amount of receding action, the *maximum* obliquity is 30°, the mean obliquity during the last half of the recess is 22° 30′, and the average obliquity during the whole action is only 17° 30′; which is well within a reasonable practical limit.

The action, when the wheel drives in the direction indicated by the arrow, begins at *m* and ends at *n*, the path of contact being made up of the straight line *m* P A and the circular arc A *n*. It might at first sight appear that because *m* A is not tangent to A *n*, there would be an effect due to this abrupt change in the direction of the path of contact, injurious to the smooth running of the wheels. But a moment's consideration will show that the effect of this change will be no more perceptible than though the entire contour of the tooth were an epicycloid with the same generating circle; for in that case, when the point of contact had reached A, the line of action would be P A, exactly as it is now; any objection to this composite tooth, then, taken upon this ground, is equally valid against the whole epicycloidal system.

In the special case illustrated in Fig. 1, the point A is the root of the involute for the pinion's tooth; but it must not be inferred that the two systems can be combined under such conditions only; it is plain that the same describing circle can be used for the epicycloidal part of the wheel's tooth, whatever the diameter of the pinion's pitch circle. Suppose the latter to be larger than here shown; then the hypocycloid generated will not be radial, nor a right line, but it will still be tangent at A to the involute of the corresponding base circle, though at a point above its root; and it will also be conjugate to the epicycloidal part of the tooth of the lower wheel.

And, in short, it is easy to construct a series of interchangeable wheels upon this composite plan, the faces of all the teeth being partly involute and partly epicycloidal, the flanks partly involute and partly hypocycloidal. This will be apparent by the aid of Fig. 3, which shows the forms of the teeth of a rack, in which the upper parts of the faces and the lower parts of the flanks are cycloids, described by rolling equal circles on opposite sides of the pitch line, and these curves are joined by tangent right lines inclined at an angle of 75° to the pitch line. Now if a series of wheels be made to work with this rack, they will work with each other indiscriminately, and the central part of the contour of each tooth will be an involute, with a constant obliquity of 15°.

It has already been suggested that the disappearance of the obliquity at the pitch point, in the action of epicycloidal teeth pure and simple, may in some circumstances prove not to be an advantage without a drawback.

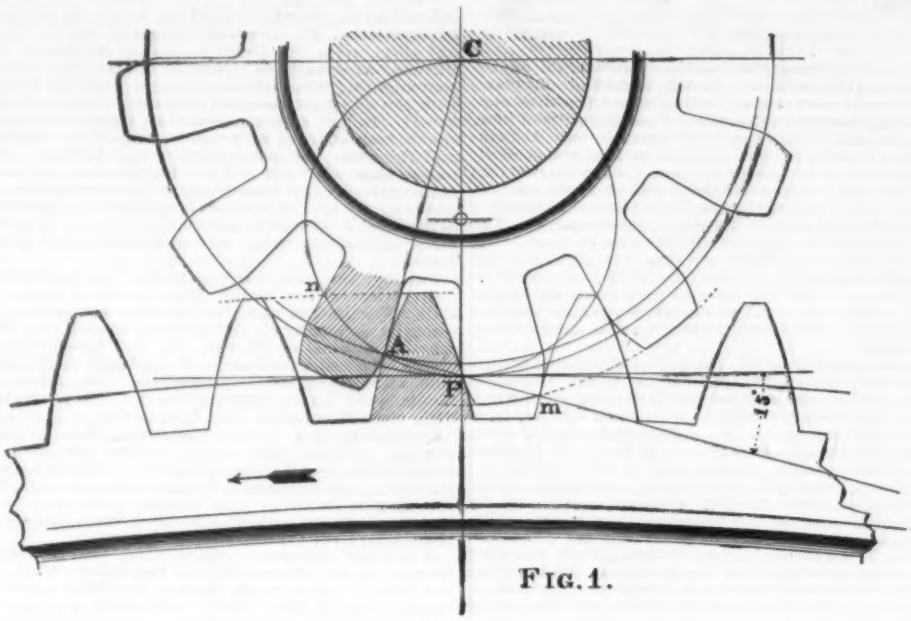


FIG. 1.

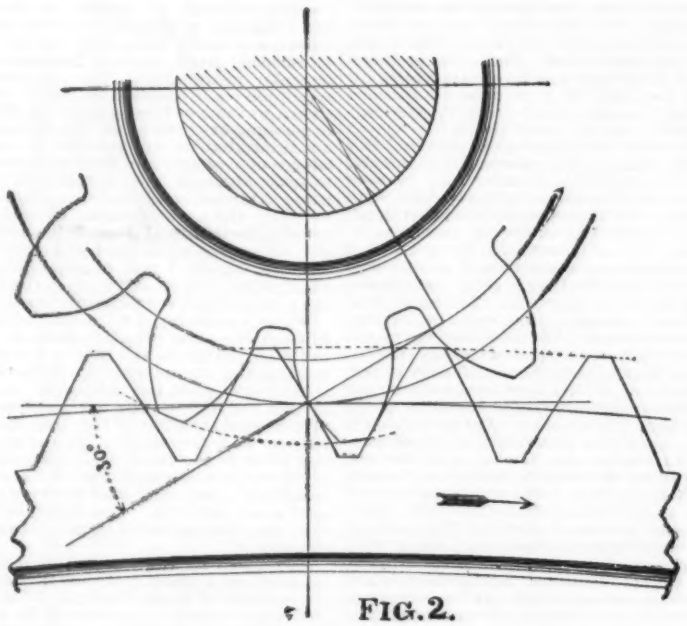
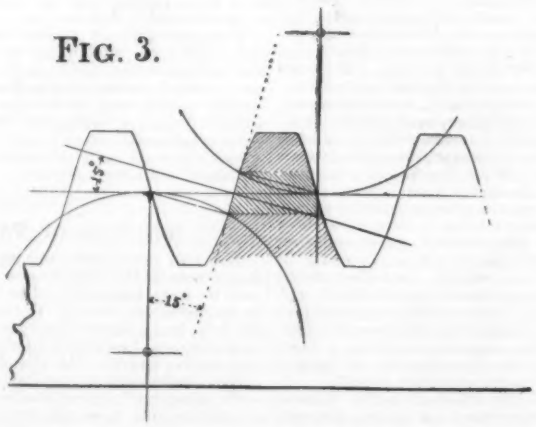


FIG. 2.

FIG. 3.



And the question may be worth considering whether the fact that at the pitch line the radius of curvature for both the face and the flank of an epicycloidal tooth is zero does not render the making of the cutter, and in some cases the cutting of the tooth, more difficult than it would be were that radius always of sensible magnitude.

If this is so, the circumstance has the same bearing in relation to making the patterns for the teeth of wheels intended to be cast; and in either case, the method of procedure above indicated provides a means of evading these difficulties, simple in principle, easy of execution, and open to no objection which does not apply with equal force to at least one of the two well-known systems thus combined.

It may be of interest to note that the abrupt change in the path of contact at A, in Fig. 1, is due to the fact that although the involute and the epicycloid forming the contour of the tooth are tangent to each other at that point, they have not the same radius of curvature. Now, referring again to Fig. 3, it will be seen that the contour of the rack tooth there shown differs but little from a sinusoidal curve. If then it were made of the exact form of the sinusoid which approximates most closely to it, the result would be that the path of contact would become a continuous curve, very flat in the region of the pitch point P in Fig. 1, at which point its tangent would coincide with the present line of action of the involute. The contour of such a rack would be as easily laid out as the one given in the figure; but the forms of the conjugate teeth for wheels of any assigned numbers of teeth could not be so readily determined. In making patterns of teeth for cast wheels, then, such a system could not well be adopted; but in the case of cut gearing, the difficulty may be easily evaded by making the rack solve the problem automatically and cut the teeth for the whole series of wheels—a process already successfully accomplished. This, however, is offered merely as a suggestion, showing that a continuous curvature of the path of contact can be easily obtained if desired, and is not

to be regarded as an intimation that it is desirable; for even theoretically this is of no possible consequence, while practically it is very desirable that the path of contact should be a simple and easily constructed line, so that in designing wheels in special cases the correct addenda for producing assigned amounts of approach and recess can be readily ascertained.

THE BERNIER HOT AIR ENGINE.

THE engine we illustrate herewith belongs to the type in which the air is forced through the fuel, the products of combustion forming the working fluid, and it is chiefly remarkable for the ingenious way in which the inventors, MM. Bernier Brothers, of Paris, have sought to avoid the defects of earlier engines. Whether this engine will prove in practice more successful than the "Bucket" engine, or any of its other predecessors, is a question which we do not propose to consider. Accurate trials have not yet been made, though we are informed that in a preliminary run the consumption of fuel was 2 lb. of ordinary coke per brake h. p. hour.

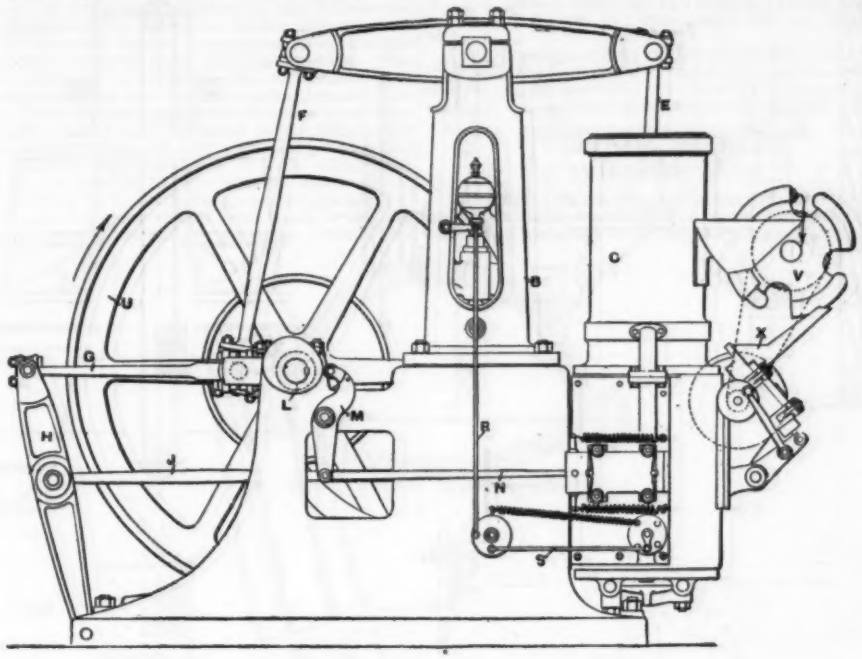
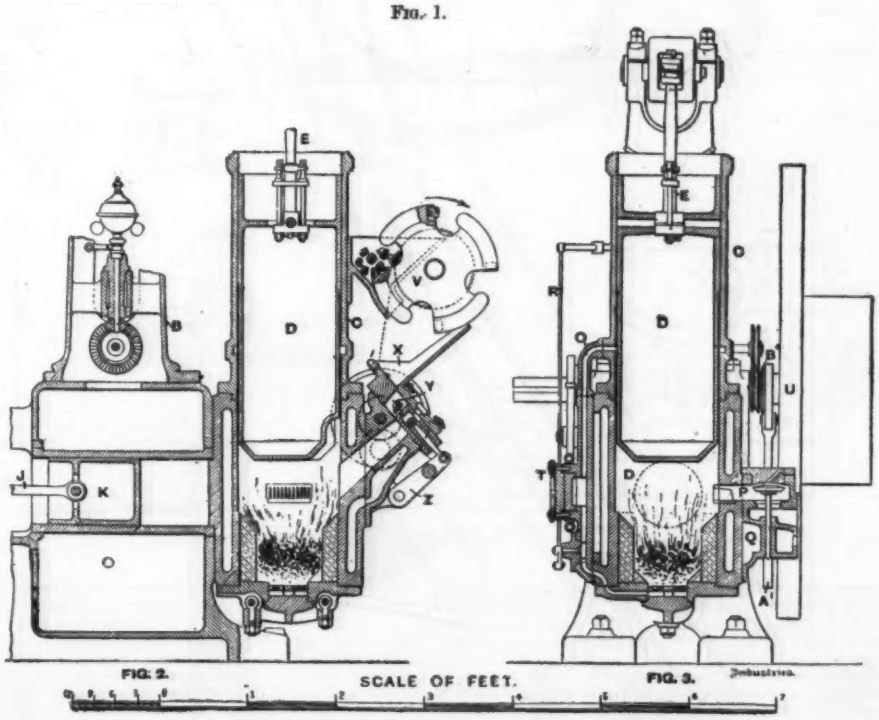


FIG. 1.



THE BERNIER HOT AIR ENGINE.

This performance, it will be seen, does not compare favorably with that of an ordinary compound steam engine; but as the trials were only approximate, it would hardly be fair to accept the figure as conclusive, and on this point we would prefer to suspend judgment until the results of more accurate trials are available. Meanwhile we may, however, give a description of this very interesting engine, which we recently saw in action at the works of Messrs. Powis Bale & Co., Appold Street, Finsbury. We may here remark that the Bernier engine has already been extensively used in France, and that also in Germany it has been taken up, and is being built in various sizes up to 25 h. p. The inventors are, however, confident that engines even up to 100 h. p. will prove practically successful.

The distinctive feature of this engine is an improvement by which the working cylinder is protected from cinders and grit, and incidentally also from contact with the working fluid, the temperature of which is necessarily very high, since the air is forced through the fire at the commencement of each stroke. The engine we illustrate in Figs. 1, 2, and 3 is a beam engine of 6 brake h. p. governed to a speed of 110 revolutions per minute. C is the working cylinder and D its plunger, which fits tight only in its upper part, and is prolonged downward, as shown in Fig. 3, the diameter of the prolonged part being slightly less than the internal diameter of the working cylinder. A narrow annular space is thus formed between the plunger and cylinder, and this space is in communication by the channel, O, with the main air supply, which is controlled by the valve, T, connecting rod, N, and cam lever, M, provided with a roller at its upper end which presses against the cam, L. The working piston is connected with the rocking beam by the rod, E, and the other end of the beam is connected with the crank by the rod, F, a second rod, G, transmitting reciprocating motion to the upper end of a lever, H, to which is joined by the rod, J, the piston, K, of the air pump. Owing to the right angular position between the rods, F and G, the piston of the air pump is at the outer end of its stroke when the working piston on its return stroke has reached a middle position, the direction of motion being as indicated by the arrow on the fly wheel, U. During the last half of the return stroke of the working piston, the air piston is pushed inward and compresses the charge of air previously drawn in until it has reached the middle of its stroke, at which moment the working piston is at the bottom of its stroke. The cam and lever is fixed in such a way that the slide valve, T, establishes communication between the air pump, the furnace, and channel, O. At this moment the fresh charge of compressed air begins to be forced partly through the fire into the furnace chamber, D, and partly through the channel, O, into the annular space previously mentioned, the flow of air continuing during the time the air piston performs the second half of its stroke. The working piston performs meanwhile the first part of its up stroke, receiving pressure from the air and products of combustion, which have been expanded by the passage through the fire. The cold air under pressure passing into the annular space through the passage, O, serves to keep the working portion of the cylinder, C, at a moderately low temperature, and also prevents grit and ashes being carried up into contact with the working faces. In fact, the air injected at O, being slightly in excess of what would be required to fill the annular space at the pressure then existing, there is a down current of comparatively cool air, which effectually protects the surface of the cylinder higher up. When the pump piston has completed its stroke, the valve, T, closes, and the hot air in the working cylinder is allowed to expand during the remainder of the up stroke of the working piston; the pump piston meanwhile drawing in a fresh supply of air through a second channel in the valve, T. When the working piston has reached the top of its stroke, the exhaust valve, P, is opened by the lever, A^1, worked from a second cam, B^1, on the crank shaft; and this valve is kept open during the descent of the working piston, which forces the gases out through the grating over the fire (shown in Fig. 2), from whence they are led into the chimney. The lower part of the working cylinder, or to speak more correctly the furnace itself, is lined with fire brick, and protected on the outside by a water jacket, Q. A water tank is fixed over the engine, and this is connected by a flow and return pipe with the water jacket, the circulation taking place automatically, very much in the same manner as in an ordinary kitchen boiler.

Since the combustion takes place under pressure, it is of course necessary to introduce the fresh fuel by means of an air lock, and in the present engine the fire, after having first been started by charcoal, is kept up by the automatic supply of coke passing through a chamber, Y, in a reciprocating slide. This slide receives motion from the lever, Z, by means of a connecting rod, joined to a crank disk, which latter is slowly revolved by a train of wheels and a gut passing over a pulley on the engine shaft. A second gut gives motion to a picking-up wheel, V, which in turning, as indicated by the arrow, lifts the coke out of the hopper, and throws it into the shoot, X. When the feeding slide, Y, is in its highest position, a piece of coke falls into its cavity, and is carried downward at the next stroke of the slide. As soon as the cavity comes opposite the inclined channel leading into the furnace, the coke is liberated, and falls into the fire. As long as the motion of the slide continues, and the upper hopper is kept charged with coke, which must be broken to pieces of convenient size, the feeding of the furnace continues automatically. The apparatus can, by means of a clutch, be thrown in or out of gear, and thus the supply of fuel can at intervals be discontinued as may be required. When the slide is in its lowest position, its cavity is opposite the furnace mouth, and a peep hole with a glass cover enables the attendant to see the state of the fire. It need hardly be mentioned that the feeding slide must be tight, since its face has to stand the working pressure, and for this reason the back plate on the slide is pressed down by springs. The speed of the engine is controlled by a governor, acting through the rods, R S, upon a throttle valve, which controls the air supply. The bottom of the grate is held up by hinged bolts, which can be quickly detached when it becomes necessary to remove ashes and clinkers.

PARIS EXPOSITION—ELEVATORS AT THE EIFFEL TOWER.

M. MAX DE NANSOUTY says that three systems of elevators will be used in the Eiffel Tower, namely: (1) The system of Roux, Combaluzier, and Lepape; (2) the Otis system; (3) the Edoux system. From the ground to where great restaurants will be established there will be four elevators, two constructed on the system of Roux, Combaluzier, and Lepape, and two on the Otis system. From thence to the second stage, where other restaurants and *salles de fetes* will be established, two Otis elevators will raise the visitors. Next to this an Edoux elevator will be used. Those who go thence to the lantern will have to climb the spiral staircase, pictured a few weeks ago in these pages.

M. G. L. Pesce, engineer of arts and manufactures, has given in *Le Genie Civil* of April 28, 1888, a description of an elevator with jointed piston, to be employed in the lower part of the Eiffel Tower. His article is accompanied by sectional drawings which are reproduced by *Engineering*, from which we take them. What follows in relation to this elevator is a translation of the memoir of M. Pesce. Mechanical ascension by impulsion has not been applied until nearly the present day, except for heights relatively small, and the system adopted has almost always been that known as the shaft or plunging piston method, with divers known variations. The elevator at the Trocadero, the piston rod of which has a stroke of 70 m., is, we believe, the largest of this kind which has been constructed of late years. Beyond this height the system seems scarcely applicable, because then serious inconveniences crop up: first, the piston has a tendency to spring; secondly, it requires a well for its accommodation.

To obviate these inconveniences while conserving the principle of the impulsion system, MM. Roux, Combaluzier, and Lepape had the idea when studying the problem of an elevator for the Eiffel Tower of replacing the rigid piston with a jointed one, to be worked by pressure like the others; in short, it may be compared to a vertebral column. It is, in fact, composed of a series of links having the form of connecting rods, attached to each other by knuckle joints. These links are, besides, furnished with two guiding friction rollers at each point of attachment. The link, thus articulated, is introduced into a round or square guideway in which it will run easily, follows all sinuosities as well as if it were a chain worked by traction. By fixing a link of this chain to the floor of an ordinary elevator cage, and impelling the flexible chain by means of a suitable wheel, driven by any motive power whatever situated at the bottom of the elevator, it is easy to see that the chain will follow the cage wherever its guides will permit it run. By joining the two extremities of the flexible chain, it will form an endless chain of rods moving over two encaged wheels. The lower wheel will apply the power, and the upper one will act as a simple pulley wheel to enable the chain to circulate.

The problem of elevators for the Eiffel Tower had to meet the following conditions: To lift 100 persons at one time with a speed of 1 m. per second; first, in the inclined part of the legs of the tower to a vertical height of 113·40 m., following a curved path of which the inclination varies from 54 deg. at the start to about 80 deg. at the finish; secondly, to then lift them in the vertical part a further height of 150 m. In the vertical height of 113·40 m. just mentioned, the actual length of the curved part will be 150 m. The mean weight to be raised will be eighteen tons, comprising: Passengers, about 100 × 70 kilos., seven tons; the weight of

the room, five tons; the weight of the two half circuits of the articulated piston, 300 m. × 17 kilos. per meter, five tons; rolling friction, estimated from types working regularly in Paris, about one ton. This weight will be distributed over two flexible pistons, fixed one on each side of the cabin, so that each piston will have to support nine tons. They will differ from endless chains in being driven by impulsion and one-half of the chain being slack. This disposition gives the advantage of relieving the upper part from the necessity of having a fulcrum destined to support the whole of the weight of eighteen tons. The upper pulley block has not, in fact, to support more than its own weight and that of the eight links which will encircle it. A counterweight will partially balance the dead weight of the cabin. This counterweight is but of three tons, which leaves the cabin a surplus weight of two tons when it is free, to permit it to descend spontaneously.

To give it power to sustain the heavy weights it will have to support, the elements of the articulated chain are formed of wrought iron cylinders, terminated by knuckle joints. These cylinders are 45 mm. in diameter, and 1 m. long between the extremities of each axle, to comply with the condition $\frac{l}{d} < 24$, which must be complied with to avoid the sagging of lengths traveling by compression. The maximum weight they will have to carry being nine tons, it will be seen that with a diameter of 45 mm. the cylinders will have to bear only 5·7 kilos. per square millimeter.

The male ends of these rods carry shoulder pieces covering by half a circumference the bearings of the female ends. These shoulder pieces prevent severing of the joints in the case of the breaking of an axle, and are in gear with the pulley wheels, as indicated. The steel axles pinning the links together are 36 mm. in diameter, and carry at their extremities the friction rollers. They will not have to bear more than 4·4 kilos. per square millimeter. Two flanges hold the rollers, and prevent them from slipping in the guide in the event of rupture of the articulation axis.

The guideway of the articulated piston may either be a cylindrical column or a caisson formed of iron plates and channels, or even simple U-shaped iron troughs. Whichever may be selected, this guide must present throughout its height a longitudinal opening to permit the free play of the pivots of suspension of the cabin. In the project given in by MM. Roux, Combaluzier, and Lepape, for the elevators of the Eiffel Tower, the guiding columns are in the form of troughs, consisting of two special rails of T-form, but furnished with ribs serving as guides for the rollers of the articulated piston, Fig. 4. The free play allowed between the rollers and their guides being about 5 mm., the pressure on the bearing surface is very small. It follows that the normal resultant of the guides is very small, and is lost in friction. The value of these resultants reaches a maximum of 1 per cent. of the total weight supported by the articulated piston, or about 90 kilos. The caisson guides are intended to be very solidly fixed to the framework of the tower.

To eliminate inequalities which may be produced in the working of two articulated pistons placed parallel to each other, to equally distribute the weight over the two circuits, the attachments to the cabin are mounted on each side by a special device, Figs. 5 and 3, consisting of two hydraulic pistons communicating with each other, by a tube. This automatically gives equality of pressure, consequently truth of level and equality of weight upon the two circuits. The cabins are each 5 m. high, and are divided into two stories. They present in the plan the position in which they will have to move. The articulated pistons are connected with each side of the cabin by pivots carrying friction rollers; the axis of suspension thus formed is a little above the center of gravity. The friction rollers work longitudinally in relation to the uprights of the framework of the tower. The cabin, while in motion, can take up variable inclinations, and to prevent this the inventors have furnished it with two guide wheels placed below the floor, and forcing it to follow two iron guiding rods placed constantly parallel to the links of the articulated piston, therefore keeping the floor constantly horizontal.

The wheels, R, Fig. 7, which give movement to the articulated pistons, are geared to the horizontal engine fixed in the basement of the tower. These wheels, Fig. 8, have their tires formed of two flanges of plate iron solidly attached, and presenting twelve segmental notches. In working the elevator, suppose the cabin to be at the top of its path, the descent will then be effected by means of a brake, under the action of a minimum surcharge of 2,000 kilos.; when it descends empty a hydraulic brake is employed, Figs. 6 and 7, having four pump cylinders, P P, P^1 P^1, of which the plungers are linked in pairs by the frames, B, and put in motion by two wrought iron cams, C, at 90 deg. on the horizontal shaft, A. These cams are designed in such a manner as to constantly drive the plungers in. The cylinders of the pumps are put into communication with each other by means of tubes, the section of which has been determined in such a manner as to oppose to the passage of the liquid a resistance enabling it to equalize the weight under the action of which the cabin will descend. With a constant weight the apparatus will travel with a constant speed, and as the resistance of the flow of the liquid will be as the square of the speed, if variations in the weight are produced, the speed at least will not vary but as the square roots of the weights. Also, by excess of precaution, an ordinary regulator may be added.

A distributor, D, placed upon the crossing of the outflow tubes, gives the power of moderating the speed of the machine, even to scotching when rising, or of stopping the cabin in its descent at any moment whatever. A reservoir, E, supplies water continuously to the four cylinders of the pump and to the junction tubes to the number of eight, of which four are for inflow and four for outflow. These tubes have valves disposed in such a manner as to force the outflow water to pass through a single tube bearing the distributor. This is worked from the cabin by a governor; it can also be worked by a mechanic placed near the machine, or even by automatic means, by which the duration and times of actions can be regulated beforehand. While the distributor is open the liquid will circulate freely and the distributor exercises the functions of a brake. Its closure, by stopping the free circulation of the liquid, stops the rotation of the pulley wheels guiding the plunging pistons, for these can no longer drive back the liquid.

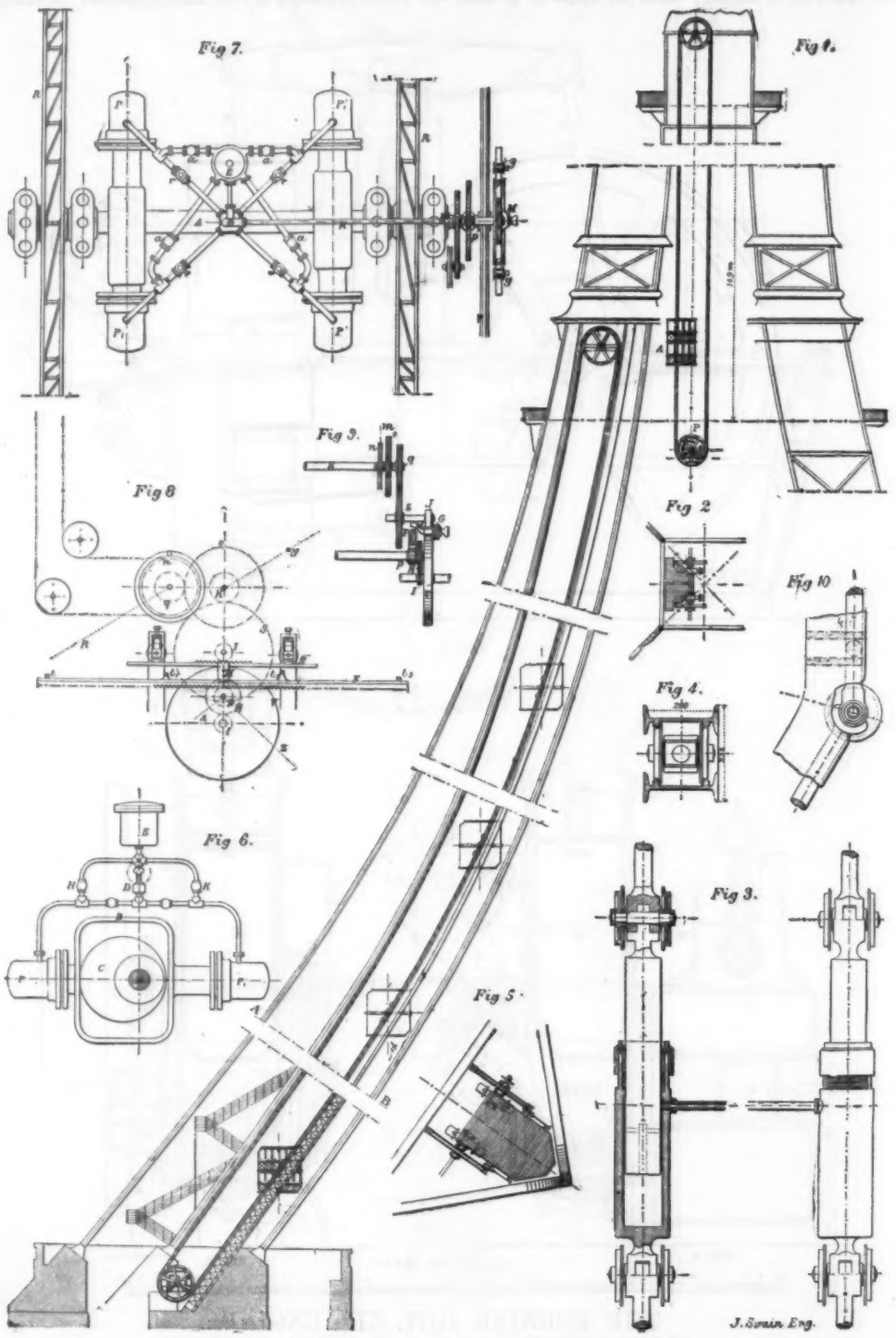
The next point is the automatic stopping of the elevator. The horizontal driving shaft, A—Figs. 7, 8, and 9—on which are fixed the hollow wheels, R, carries at its extremity a pinion, *p*, which works into a long rack, representing, on a reduced scale, the total course of the elevator. This rack carries the studs, t t_1 t_2 t_3, corresponding to the positions of the stoppages it is desired to make automatically. These studs meet, by the displacement of the rack, a monitor box, M, which drives the distributor by the interposition of a little rack of which it forms part. The horizontal shaft is terminated by a cogwheel, H, and by the pinion, I, communicates its motion to a great friction roller, V, which gives continuous support to the back of a small rack and tends to drag it in an opposite direction to that of the motor shaft. This rack is strongly forced down by the spring friction rollers, *g*, on the friction wheel and by a pinion, J, which, by a train of gearing, transmits the movement to the governing shaft, *k*, of the distributor, D. In normal ascensions the friction carrier tends to keep the distributor constantly open. If, on the contrary, the motive power fails from any cause whatever, the driving shaft, under the action of the weight, begins to turn in a contrary direction to that which is produced by the ascending motion, and the little rack determines the closing of the distributor. The same thing takes place when in the ascensional course the monitor box comes into contact with the studs, fixed on the great rack. The distributor then closes gradually, and the machine is stopped.

The governing of the distributor is effected from the cabin by moving by a hand fly-wheel the working rope, which passes over a grooved pulley, *n*, Fig. 8, geared up with the shaft of the distributor, *k*. To make a start, the distributor is opened at the same time that the contact of the friction rollers, *g*, on the rack, G, is made. The mechanic near the machine can also directly control the distributor and stop the cabin at any level whatever.

M. Pesce adds that this elegant solution of a new and difficult problem by the inventors shows how widely the system can be applied, and that it is ingeniously simple. He gives the following figures:

Speed per second	1 m.
Engines	180 horse power.
Lifting power.	100 persons.
Vertical course.	149 m.
In the inclined part of the tower	Vertical course, 113·50 m Real course, 160·00 m.

The elevators to the second stage, and in two of the legs of the tower, made according to the system of Messrs. Otis Bros., of New York, present, according to M. Nansouty, the double advantage in attaining great heights of not requiring a deep well and of traveling at great speed; they are also well under command. The two Otis elevators to be used will carry but fifty persons, but as their speed will be double that of the cabins on the articulated piston, they will do the same amount of work; their speed will be 2 m. per second. A cast iron cylinder, 0·95 m. in diameter and about 11 m. long, will be placed in the foot of the tower, perpendicularly to the inclination of the cross pieces of the legs thereof. In this cylinder is a piston fed with water from reservoirs placed on the second stage, consequently exerting a pressure of from 11 to 12 atmospheres. The piston rod operates on a carriage bearing six guide wheels 1·40 m. in diameter. Each of these guide wheels corresponds to a fixed one of the same diameter in such a way as to constitute a single gigantic pulley. The tackle passes over pulley blocks placed here and there up to the second stage, and redescends to hold the cabin. The result is that for a movement of 1·0 m. by the piston in the cylinder the cabin rises or falls 12 m. To partly counterbalance the cabin, a weight will be used. Six ropes of steel wire will suspend the cabin two of these will be connected with the counterpoise and four with the system of pulleys. One of these ropes alone will have sufficient strength to bear the cabin full of passengers without breaking. Under the cabin will be placed a safety brake with jaws working automatically in case of rupture, or even of elongation of one of the ropes. The counterpoise is also provided with safety apparatus. M. Nansouty says that 15,000



HYDRAULIC ELEVATOR, EIFFEL TOWER.

of these elevators are working in the United States, and have never caused a single accident.

The Edoux elevator, in which a cabin is raised upon an enormous piston, as at the Trocadero, will be used to reach the third stage of the tower. This elevator has already been described in these pages.

SHAPING SHEET METAL BY FLUID PRESSURE.

THE following description of a method of shaping zinc, copper, and other ductile metals by fluid pressure was contributed by Mr. D. W. Kemp, of Leith, to the Royal Scottish Society of Arts, and the following is from the recently issued *Transactions* of the Society. The following improvements in shaping ductile metals by surface tension and diffusion, to form concave, indented, or hollow articles, are the subject of letters patent, and have been provisionally protected. The initial idea is largely due to Mr. James Kirkwood. Mr. John Kirkwood, zinc-bath maker, Leith, assisted by Mr. James Kirkwood, put the idea to a practical test, and independently I carried out several experiments; since then we have been developing the process together. The invention consists in taking advantage to the full of the well known properties in all ductile metals to flow or stretch under gradual pressure. The methods ordinarily followed in the manufacture of hollow metal articles are by hammering, cressing, or spinning. Two copper pans, extraordinary specimens of hammered work, were exhibited in the Edinburgh International Exhibition of 1886. The larger pan was 9 ft. 6 in. internal diameter by 3 ft. 3 in. deep, and weighed 13 cwt. 2 qr. 20 lb.; the smaller one was 6 ft. internal diameter by 3 ft. 6 in. deep, and weighed 7 cwt. 2 qr. 3 lb. An ordinary tinned iron basin is a good specimen of cressed, struck, or stamped work. The tinned copper hemispheres, for making balls for the end of levers of cistern stop cocks, are beautiful specimens of metal spinning.

The improvement we claim over those methods may be called blowing, and consists in employing fluid pressure and heat, in combination with suitable moulds. The pressure must be applied in such a manner on the sheet metal as will force it gradually and steadily into the concave or hollow part of a mould shaped internally to fit the external shape intended to be given. Thus if a sheet of zinc is to be shaped into a basin form or into a dome, a cast-iron mould is made consisting of two parts, one of which is of the required form, and has a flat flange round its edge, while the other is a cover of a nearly flat form, and has a flange which can be bolted or otherwise tightly fastened to the flange of the other part. The sheet zinc is fixed between the two parts of the mould, and steam or other fluid under pressure is admitted between the zinc sheet and the cover of the mould, and produces the desired effect. Glass blowing and the boy's soap bubble may be cited in illustration of small flat surfaces being stretched by pressure into a curved form.

The large dome now exhibited was made by this process by Mr. Kirkwood. It is of sheet zinc about one-tenth inch thick, internal diameter 2 ft. 4 in. by 1 foot deep. To accomplish such a piece of work by any other process would require costly machinery. This dome was made in about half an hour with the simplest appliances—only a pipe from a high pressure boiler and a mould. The numerous small specimens exhibited I have made by direct pressure, similar to the experiment now proceeding on the table. It will be seen that the mould is also the boiler, and steam pressure is obtained by means of a Bunsen gas lamp. The internal diameter of the dome-shaped zinc vessel is 12 in., and a depth (or, as it appears, height) of 4¾ in. may be easily reached before the zinc will rupture. The pressure should be applied gradually and steadily; if too great, or applied suddenly, the metal will break.

With metals of good and uniform quality the fluid pressure will impart a spheroidal or similar form without a mould surface, and when worked in this way heat may be applied directly to the outside of the sheet that is being operated on.

The pressure and heat required will vary with the kind of metal and the thickness. In some cases heated and compressed air may be used with advantage, or any suitable gas or vapor, or a heated liquid, water, oil, etc., under pressure, and if found desirable in any cases, heat may be applied to the exterior of the mould either in addition to or instead of heat being applied to the pressing fluid, prior to such fluid being introduced into the mould.

Zinc expands the most and platinum the least under the influence of heat. The following figures show the expansion between the freezing and boiling points of water of a rod 100,000 in. long: Zinc, 298 in.; lead, 282 in.; tin, 196 in.; silver, 193 in.; copper, 171 in.; gold, 144 in.; iron (soft), 120 in.; iron (cast), 109 in.; platinum, 87 in.

Apart from the utility of the invention in the industrial arts, the simplicity of the process to illustrate the elongation, expansibility, and flowing of certain metals makes it a beautiful lecture table experiment.

FIG. 2.

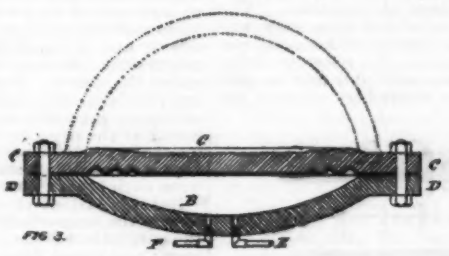
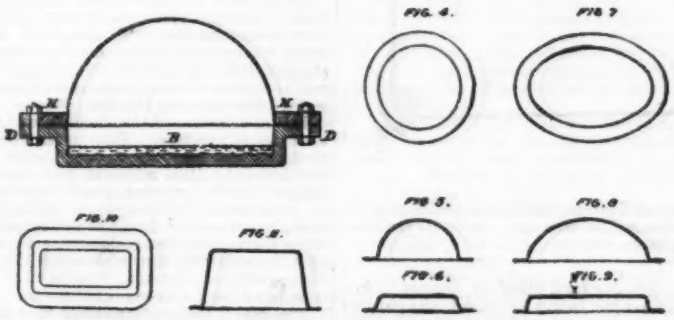


FIG. 3.



METAL SHAPING BY FLUID PRESSURE.

[AMERICAN CHEMICAL JOURNAL.]

SULPHURIC ACID.

Materials of Sulphuric Acid Manufacture.—The first sulphuric acid manufactured was "fuming" acid, which was obtained in Bohemia by distilling ferric sulphate. The manufacture from sulphur was introduced in England in 1740. After that time sulphur was generally used until about 1833, when Perret & Sons, of Chessy, near Lyons, began to utilize in sulphuric acid making the sulphur dioxide given off in the burning of copper ores. The monopoly of the exportation of Sicilian sulphur, granted in 1838 to a firm in Marseilles, though of brief duration, caused a general search for other sources of sulphur. Deposits of pyrites were developed in Westphalia, Hungary, France, Belgium, Ireland, and other countries, which supplied the wants of Europe for a long period. The pyrites from these sources have now been almost entirely supplanted by the cupreous pyrites of Spain and Portugal, which is burned chiefly for the copper and silver which it contains, with the production of sulphuric acid as a by-product. The use of sulphur for acid making has been almost wholly abandoned in Europe. In 1887 there were imported into England 597,595 tons of pyrites and only 32,634 tons of sulphur.

In the United States important deposits of pyrites occur, chiefly in New Hampshire, Massachusetts, and Virginia; the total quantity produced from these sources amounted in 1887 to 53,233 tons. During the same year there were imported from Canada about 35,000 tons and from Spain 16,600 tons. The importation of sulphur from Sicily amounted in 1887 to 88,593 long tons. As these figures show, sulphur is still more generally used than pyrites in the United States for the manufacture of sulphuric acid. It was estimated* that in 1884, 306,000 tons of acid were made from sulphur and 122,000 tons from pyrites. In 1887 only four additional works had taken up the use of pyrites. The reason of this delay in the introduction of pyrites on the part of American manufacturers is probably the great demand for sulphuric acid in this country for the manufacture of fertilizers and the refining of petroleum; the price of acid is therefore comparatively high, and the practice of rigid economy unnecessary. The introduction of pyrites has also to contend against the higher cost and more complicated working of the apparatus which its use involves. Another advantage of sulphur is that it produces acid free from arsenic, an important consideration if the acid is to be used in the manufacture of chemicals used in the preparation of food or medicines, though of no consequence in the petroleum or fertilizer industries. Further, when sulphur is used, the burner gases are somewhat richer than those from pyrites, since in the latter case a portion of the oxygen of the air admitted remains behind in the oxide of iron of the cinders. Lunge† calculates that one kilogramme of free sulphur gives 6,109 liters of gas, while the same weight of sulphur in the form of pyrites gives 8,145 liters. This renders it necessary to provide one-fourth to one-third more chamber space for pyrites than for sulphur. There can, however, be no question that pyrites is decidedly the cheaper material, especially when the cinders are worked for copper. Dr. Francis Wyatt, in his valuable review of the development of American chemical industry,‡ estimates that by the manufacture of acid at the pyrites mines the cost might be reduced from $5.50 to $4.20 per ton of chamber acid. To compete with this, brimstone must be sold at $14 per ton, whereas the price in 1887 ranged from $19 to $24.

Generally speaking, works near Philadelphia and in the South are still using sulphur, while in the more complete and modern plants in the neighborhood of New York and in New England pyrites is employed.

Extraction of Sulphur.—The methods of extracting sulphur from the gangue in Sicily have been greatly improved in recent years by the introduction of larger kilns for burning the ore. According to Consul Carroll,‡ these have, in some cases, the capacity of 5,000 tons each, and the smelting operation requires several months for its completion. In these kilns from two-fifths to three-fifths of the sulphur contained in the ore is obtained, or from two to three times as large a proportion as in the small kilns formerly used. More perfect methods of extraction are employed in Sicily to some extent, but owing to the scarcity of fuel, costliness of machinery, and lack of intelligent labor, the greater part of the sulphur is still obtained by means of the "calcaroni" or large kilns. According to Vincent,§ the process of Tour and Debreuil has been introduced into Sicily. This consists in immersing the ore, contained in iron baskets, in a solution of calcium chloride heated to 130° C., or above the melting point of sulphur. By this process it is possible to extract all but four or five per cent. of the sulphur contained in the ore. Consul Carroll states that Durand's process of fusion in iron pots and ladling out the melted sulphur, Hirzel's furnace, Thomas' process of fusion by superheated steam, and Bollmann's method of extraction by carbon disulphide, are also to some extent used.

In the United States sulphur is obtained on a commercial scale only at Cove Creek, Utah. The deposits are stated to be very extensive, and the production of sulphur has rapidly increased during the past few years. In 1887 the amount obtained was about 3,000 tons. The sulphur is extracted by fusion with superheated steam. Cedar wood for fuel is abundant and cheap.

Pyrites Burners.—The furnaces used for burning pyrites have been often described, and no important changes have been lately introduced. The forms generally used in Europe and this country are grate burners for lump ore, and shelf burners for "smalls." The "Spence Mechanical Furnace," now largely used in Europe and at some works in this country, is a shelf burner for small ore in which the charge is pushed from one shelf to another by steam power instead of by hand.

Utilization of Pyrites Residue.—With modern burners for smalls, and especially with the Spence furnace, it is possible to burn the pyrites down to one per cent. of sulphur. The resulting cinders from non-cupreous pyrites consist chiefly of ferric oxide, and are almost absolutely free from phosphorus. Such cinders are valuable as iron ore. According to Dr. Wyatt, several acid works near New York are now selling their non-cupreous pyrites cinders to iron smelters at three or four dollars per ton.

Cinders from pyrites containing notable quantities of copper are treated by the wet extraction process. If much silica and little silver are present, as in the case of cinders from most kinds of American pyrites, it is found best to smelt the cinders with the addition of raw pyrites in the form of "fines," and thus to obtain a "matte" containing 50 to 60 per cent. of copper. By this method, however, the iron and silver contained in the cinders are lost. If, on the other hand, there are present two or three ounces per ton of silver and but little silica, as is generally the case with the cinders from Spanish ores, the Henderson wet process is used for the extraction of copper and silver.

It is stated that 400,000 tons of pyrites residue are annually treated by this process in England alone. The cinders are roasted with salt, sometimes with the addition of the mattes obtained by smelting siliceous ores. The cinders contain copper, chiefly in the form of sulphate and sulphide. After roasting with salt the copper is principally in the form of chloride, with a considerable proportion of oxide. Hydrochloric acid is given off during the roasting, and is condensed in the usual way. The resulting cinders are lixiviated, first with water, then with the dilute acid obtained in the operation. In the solution the silver is precipitated by potassium iodide or hydrogen sulphide, and the copper by scrap iron. This process is worked to some extent in this country, using the residues from Spanish pyrites, at Elizabeth, N. J., Natrona, Pa., and probably at other places.

Modern Acid Works.—The use of the Glover tower has become general in Europe, but has not been taken

* Mineral Resources of the United States, 1883-4.

* "Sulphuric Acid and Alkali," vol. i., p. 340.

† "Engineering and Mining Journal," 1887, and "Mineral Resources," 1886, p. 671.

‡ U. S. Consular Reports, No. 92, 1888, p. 182.

§ Trans. by Bayley.—*American Chemical Journal*, 6, 63.

up by more than one-half the works in this country. Near New York and in New England, however, are located several new works at which highly concentrated acid for use in refining petroleum and in making nitro-glycerine is made. These establishments are generally equipped with all the best appliances, such as shelf burners for smalls, Glover and Gay-Lussac towers, and platinum concentrating apparatus, and are as complete and perfect as any works in Europe.

Concentration of Sulphuric Acid.—The chamber acid has generally a strength not above 50° B., corresponding to about 62 per cent. of H_2SO_4. This is strong enough for the manufacture of superphosphates, ammonium sulphate, and even for the salt cake process. For the refining of petroleum, the manufacture of nitric acid, and especially in making nitro-compounds, acid of greater strength is needed. Acid from the Glover tower may reach a strength of 62° B., corresponding to 81·7 per cent. of H_2SO_4. Beyond this point the concentration must be carried on in platinum stills or glass retorts. Acid from the Glover tower cannot generally be concentrated in platinum, since it contains a large amount of ferric sulphate, which would deposit on the pan and do serious damage. When platinum stills are used, therefore, acid from the chambers is first concentrated in lead pans by the waste heat of the platinum stills or burners to 60° B., then run into the stills. In this country these are generally on the Faure and Kessler system, and consist of a pan of platinum, surmounted by a leaden dome cooled by a water jacket. The great drawback to the use of platinum is its rapid corrosion, which is especially marked in the case of acid containing nitrogen compounds or considerable quantities of arsenic. Acid made from sulphur is free from arsenic, and that made from American pyrites is practically so. The oxides of nitrogen must be completely removed before distillation in platinum is attempted. This is done by the addition of a little ammonium sulphate, which decomposes the nitrogen compounds, forming water and free nitrogen.

According to W. H. Adams,* platinum stills would last almost indefinitely for the concentration of acid free from arsenic up to a strength of 65° B., or about 90 per cent. H_2SO_4. Such acid is strong enough for almost all purposes, but for the manufacture of nitro-benzene, nitro-glycerine, etc., further concentration is necessary. Beyond this point lead, iron, and other substances are rapidly precipitated and adhere to the bottom of the pan, causing its speedy destruction, and it is in the removal of the last portions of water that the chief injury to the apparatus takes place. Within the last few years cast iron retorts have been successfully used for the final concentration, and are now employed on a large scale in extensive works near New York. It is found that acid of 65° B. does not attack the stills, and no injury appears to result from the deposition of arsenic or other substances. The concentration is carried as far as possible in platinum; the acid is then run into the cast iron stills and concentrated to 98 per cent. H_2SO_4. It is stated by Mr. Adams that a set of iron stills such as he describes is in use near New York in connection with platinum, and is producing 30,000 pounds per day of 98 per cent. acid.

In England the use of glass seems to be increasing, owing to the cheapness and perfection of the large retorts which are now made. By the use of glass, acid from the Glover tower may be concentrated directly, and no injury results from the presence of arsenic or nitrogen compounds. The final concentration, however, presents many difficulties, owing to the violent ebullition of the strong acid and the separation of sediments. The loss by breakage is therefore still very great.

SPENCER B. NEWBURY.

"PLATINO-URANOTYPE" AND "MERCURO-URANOTYPE," TWO NEW URANIUM PRINTING PROCESSES.†

A COLD solution in the first place obviously is desirable, and the following seems to be suitable: First, make a saturated solution of neutral oxalate of potash, and dissolve dry ferrous oxalate in this to saturation. By the use of this cold development I got over my main difficulties, for I have, as you shall see later, obtained platinum prints in half tones, and it is to prints thus obtained that I have given the name of "platino-uranotype."

It will be needless to call your attention to the fact that, like Artemus Ward's tale, "they are far from purfick," but they will serve the purpose of affording proof of my success so far as the rough chemical problem is concerned. The refinement and perfection of the process can only be achieved by repeated and patient trial, in order to ascertain the best proportions of the sensitizing solutions, etc., and my object in bringing the matter before your notice at this very early stage is in the hope that far more competent hands than my own may be started in this direction. The process is very simple, for the operations involved are merely:

1. Coating the paper.
2. Exposing same in printing frame.
3. Development (which takes only five to ten seconds).
4. Fixing in HCl (one and a half per cent. solution).
5. Rinsing in water, drying, and mounting.

In my most recent experiments I have substituted the uranium chloride for the nitrate in the sensitizing solution, and I am inclined to think that better results are to be obtained from its use. As in Mr. Willis' processes, chlorate of potash may be added in minute quantities to the sensitizing solution to increase contrasts.

As far as my necessarily limited knowledge at present goes, the following seems good proportions for the sensitizing solutions:

A.

Saturated solution of uranium chloride.

B.

Potassic platinous chloride..... 60 grains.
Water, distilled..... .... 1½ ounces.

Ninety minims each of A and B are spread over a well-sized sheet of paper, 26x20 inches.

Now for the most perfect form of platinotype (by any process) to be obtained, it is not difficult to see that the platinum should not form a part of the sensitizing solution, but should be deposited on an image already formed, by an action similar to that of toning silver prints with gold, and for this reason no platinum in the "paper" or "printing-out" process can ever give the detail of a silver print. I have experimented with a view to a modification of the platino-uranotype process with but partial success, and it is through these experiments that I arrived at what, so far as I can ascertain, is a second novel process—"mercuro-uranotype." This is the title which I have given to this second process, which may turn out to be useful for rapid proofing of negatives, if for nothing else, for the tone is not very objectionable, and if preferred may be modified. Paper is coated with one or the other of our uranium solutions, to which has been added some saturated solution of mercury bichloride (say one part mercury solution for every eight of the uranium solution). A sheet of paper is coated with about one hundred and seventy minims of this solution and dried in the dark. It is then printed behind a negative until it attains full strength, which will take only a few minutes; it may then be floated on solutions of gold or platinum to obtain a more pleasing tone, and next placed in water acidulated with HCl, or the toning omitted and the print treated as if it were Pizzighelli paper. Thus it will be seen that this process is one of the simplest known.

In conclusion, then, may I venture to say that if more attention were directed to the salts of uranium many latent and valuable properties would in all probability be discovered; their reactions are very powerful and should be more generally known than they are at present. I believe much remains to be discovered in this direction.

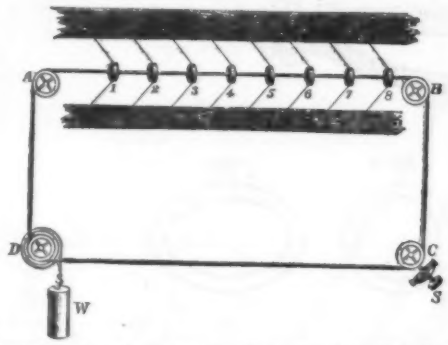
As to the "platino-uranotype" process, the rough prints I have here will afford proof of my success in obtaining pictures in platinum black by novel means; and I may tell you that throughout my experiments with this process I checked results by treating prints on plain uranium paper in the same manner as the others, in order to make certain that the appearances observed were wholly due to the presence of platinum salts.

ALLEYNE REYNOLDS.

THE DISCHARGE OF A LEYDEN JAR.*

By Prof. OLIVER J. LODGE.

IT is one of the great generalizations established by Faraday, that all electrical charge and discharge is essentially the charge and discharge of a Leyden jar. It is impossible to charge one body alone. Whenever a body is charged positively, some other body is *ipso facto* charged negatively, and the two equal opposite charges are connected by lines of induction. The charges are, in fact, simply the ends of these lines, and it is as impossible to have one charge without its correlative as it is to have one end of a piece of string without there being somewhere, hidden it may be, split up into strands it may be, but somewhere existent, the other end of that string.



Mechanical analogy of a circuit partly *dielectric;* for instance, of a charged condenser. A is its positive coat, B its negative.

This, I suppose, familiar fact, that all charge is virtually that of a Leyden jar, being premised, our subject for this evening is at once seen to be a very wide one, ranging in fact over the whole domain of electricity. For the charge of a Leyden jar includes virtually the domain of electrostatics; while the discharge of a jar, since it constitutes a current, covers the ground of current electricity all except that portion which deals with phenomena peculiar to steady currents. And since a current of electricity necessarily magnetizes the space around it, whether it flow in a straight or in a curved path, whether it flow through wire or burst through air, the territory of magnetism is likewise invaded; and inasmuch as a Leyden jar discharge is oscillatory, and we now know the vibratory motion called light to be really an oscillating electric current, the domain of optics is seriously encroached upon.

But though the subject I have chosen would permit this wide range, and though it is highly desirable to keep before our minds the wide-reaching import of the most simple seeming fact in connection with such a subject, yet to-night I do not intend to avail myself of any such latitude, but to keep as closely and distinctly as possible to the Leyden jar in its homely and well-known form, as constructed out of a glass bottle, two sheets of tinfoil, and some stickphast.

The act of charging such a jar I have permitted myself now for some time to illustrate by the mechanical analogy of an inextensible endless cord able to circulate over pulleys, and threading in some portion of its length a row of tightly gripping beads which are connected to fixed beams by elastic threads.

The cord is to represent electricity; the beads represent successive strata in the thickness of the glass of the jar, or, if you like, atoms of dielectric or insulating matter. Extra tension in the cord represents negative potential, while a less tension (the nearest analogue to pressure adapted to the circumstances) represents positive potential. Forces applied to move the cord, such as winches or weights, are electro-motive forces; a clamp or fixed obstruction represents a rheostat or contact breaker; and an excess or defect of cord between two strata of matter represents a positive or a negative charge.

The act of charging a jar is now quite easily depicted as shown in the diagram.

To discharge the jar one must remove the charging E. M. F. and unclamp the screw, *i. e.*, close the circuit. The stress in the elastic threads will then rapidly drive the cord back, the inertia of the beads will cause it to overshoot the mark, and for an instant the jar will possess an inverse charge. Back again the cord swings, however, and a charge of same sign as at first, but of rather less magnitude, would be found in the jar if the operation were now suspended. If it be allowed to go on, the oscillations gradually subside, and in a short time everything is quiescent, and the jar is completely discharged.

All this occurs in the Leyden jar, and the whole series of oscillations, accompanied by periodic reversal and re-reversal of the charges of the jar, is all accomplished in the incredibly short space of time occupied by a spark.

Consider now what the rate of oscillation depends on. Manifestly on the elasticity of the threads and on the inertia of the matter which is moved. Take the simplest mechanical analogy, that of the vibration of a loaded spring, like the reeds in a musical box. The stiffer the spring and the less the load, the faster it vibrates. Give a mathematician these data, and he will calculate for you the time the spring takes to execute one complete vibration, the "period" of its swing. [Loaded lath in vise.]

The electrical problem and the electrical solution are precisely the same. That which corresponds to the flexibility of the spring is in electrical language called static capacity, or, by Mr. Heaviside, permittance. That which corresponds to the inertia of ordinary matter is called electro-magnetic inertia, or self-induction, or, by Mr. Heaviside, inductance.

Increase either of these, and the rate of oscillation is diminished. Increasing the static capacity corresponds to lengthening the spring; increasing the self-induction corresponds to loading it.

Now, the static capacity is increased simply by using a larger jar, or by combining a number of jars into a battery in the very old established way. Increase in the self-induction is attained by giving the discharge more space to magnetize, or by making it magnetize a given space more strongly. For electro-magnetic inertia is wholly due to the magnetization of the space surrounding a current, and this space may be increased or its magnetization intensified as much as we please.

To increase the space we have only to make the discharge take a long circuit instead of a short one. Thus we may send it by a wire all round the room, or by a telegraph wire all round a town, and all the space inside it and some of that outside will be more or less magnetized. More or less, I say, and it is a case of less rather than more. Practically very little effect is felt except close to the conductor, and accordingly the self-induction increases very nearly proportionally to the length of the wire, and not in proportion to the area inclosed; provided also the going and return wires are kept a reasonable distance apart, so as not to encroach upon each other's appreciably magnetized regions.

But it is just as effective, and more compact, to intensify the magnetization of a given space by sending the current hundreds of times round it instead of only once; and this is done by inserting a coil of wire into the discharge circuit.

Yet a third way there is of increasing the magnetization of a given space, and that is to fill it with some very magnetizable substance, such as iron. This, indeed, is a most powerful method under many circumstances, it being possible to increase the magnetization and therefore the self-induction or inertia of the current some 5,000 times by the use of iron.

But in the case of the discharge of a Leyden jar iron is of no advantage. The current oscillates so quicky that any iron introduced into its circuit, however subdivided into thin wires it may be, is protected from magnetism by inverse currents induced in its outer skin, as your professor of natural philosophy * has shown, and accordingly it does not get magnetized; and so far from increasing the inductance of the discharge circuit, it positively diminishes it by the reaction effect of these induced currents; it acts, in fact, much as a mass of copper might be expected to do.

The conditions determining rate of oscillation being understood, we have next to consider what regulates the damping out of the vibrations, *i. e.*, the total duration of the discharge.

Resistance is one thing. To check the oscillations of a vibrating spring you apply to it friction, or make it move in a viscous medium, and its vibrations are speedily damped out. The friction may be made so great that oscillations are entirely prevented, the motion being a mere dead beat return to the position of equilibrium; or, again, it may be greater still, and the motion may correspond to a mere leak or slow sliding back, taking hours or days for its accomplishment. With very large condensers, such as are used in telegraphy, this kind of discharge is frequent, but in the case of a Leyden jar discharge it is entirely exceptional. It can be caused by including in the circuit a wet string, or a capillary tube full of distilled water, or a slab of wood, or other atrociously bad conductor of that sort; but the conditions ordinarily associated with the discharge of a Leyden jar, whether it discharge through a long or short wire, or simply through its tongs, or whether it overflow its edge or puncture its glass, are such as correspond to oscillations, and not to leak. [Discharge jar first through wire and next through wood.]

When the jar is made to leak through wood or water, the discharge is found to be still not steady; it is not oscillatory indeed, but it is intermittent. It occurs in a series of little jerks, as when a thing is made to slide over a resined surface. The reason of this is that the terminals discharge faster than the circuit can supply the electricity, and so the flow is continually stopped and begun again.

Such a discharge as this, consisting really of a succession of small sparks, may readily appeal to the eye as a single flash, but it lacks the noise and violence of the ordinary discharge; and any kind of moving mirror will easily analyze it into its constituents and show it to be

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* Twenty Years' Progress in the Concentration of Sulphuric Acid; Proc. of Amer. Inst. of Mining Engineers, 1887.

† A communication made to the Sheffield Photographic Society. Reported in the *British Journal of Photography.*

* Friday evening discourse at the Royal Institution of Great Britain, on March 8, by Prof. Oliver J. Lodge, F.R.S.—*Nature.*

* Lord Rayleigh.

intermittent. [Shake a mirror, or waggle head or opera glass.]

It is pretty safe to say, then, that whenever a jar discharge is not oscillatory it is intermittent, and when not intermittent is oscillatory. There is an intermediate case when it is really dead beat, but it could only be hit upon with special care, while its occurrence by accident must be rare.

So far I have only mentioned resistance or friction as the cause of the dying out of the vibrations; but there is another cause, and that a most exciting one.

The vibrations of a reed are damped partly indeed by friction and imperfect elasticity, but partly also by the energy transferred to the surrounding medium and consumed in the production of sound. It is the formation and propagation of sound waves which largely damp out the vibrations of any musical instrument. So it is also in electricity. The oscillatory discharge of a Leyden jar disturbs the medium surrounding it, carves it into waves which travel away from it into space; travel with a velocity of 185,000 miles a second; travel precisely with the velocity of light. [Tuning fork.]

The second cause, then, which damps out the oscillations in a discharge circuit is *radiation; electrical* radiation if you like so to distinguish it, but it differs in no respect from ordinary radiation (or "radiant heat" as it has so often been called in this place); it differs in no respect from light except in the physiological fact that the retinal mechanism, whatever it may be, responds only to waves of a particular and that a very small size, while radiation in general may have waves which range from 10,000 miles to a millionth of an inch in length.

The seeds of this great discovery of the nature of light were sown in this place; it is all the outcome of Faraday's magneto-electric and electrostatic induction; the development of them into a rich and full-blown theory was the greatest part of the life work of Clerk-Maxwell; the harvest of experimental verification is now being reaped by a German. But by no ordinary German. Dr. Hertz, now professor in the Polytechnicum of Karlsruhe, is a young investigator of the highest type. Trained in the school of Helmholtz, and endowed with both mathematical knowledge and great experimental skill, he has immortalized himself by a brilliant series of investigations which have cut right into the ripe corn of scientific opinion in these islands, and by the same strokes as have harvested the grain have opened up wide and many branching avenues to other investigators.

At one time I had thought of addressing you this evening on the subject of these researches of Hertz, but the experiments are not yet reproducible on a scale suited to a large audience, and I have been so closely occupied with some not wholly dissimilar, but independently conducted, researches of my own—researches led up to through the unlikely avenue of lightning conductors—that I have had as yet no time to do more than verify some of them for my own edification.

In this work of repetition and verification Prof. Fitzgerald has, as related in a recent number of *Nature* (Feb. 21, p. 391), probably gone further; and if I may venture a suggestion to your honorary secretary, I feel sure that a discourse on Hertz's researches from Prof. Fitzgerald next year would be not only acceptable to you, but would be highly conducive to the progress of science.

I have wandered a little from my Leyden jar, and I must return to it and its oscillations. Let me very briefly run over the history of our knowledge of the oscillatory character of a Leyden jar discharge. It was first clearly realized and distinctly stated by that excellent experimentalist, Joseph Henry, of Washington—a man not wholly unlike Faraday in his mode of work, though doubtless possessing to a less degree that astonishing insight into intricate and obscure phenomena; wanting also in Faraday's circumstantial advantages.

This great man arrived at a conviction that the Leyden jar discharge was oscillatory by studying the singular phenomena attending the magnetization of steel needles by a Leyden jar discharge, first observed in 1824 by Savary. Fine needles, when taken out of the magnetizing helices, were found to be not always magnetized in the right direction, and the subject is referred to in German books as anomalous magnetization. It is not the magnetization which is anomalous, but the currents which have no simple direction; and we find in a memoir published by Henry in 1842 the following words:

"This anomaly, which has remained so long unexplained, and which, at first sight, appears at variance with all our theoretical ideas of the connection of electricity and magnetism, was, after considerable study, satisfactorily referred by the author to an action of the discharge of the Leyden jar which had never before been recognized. The discharge, whatever may be its nature, is not correctly represented (employing for simplicity the theory of Franklin) by the single transfer of an imponderable fluid from one side of the jar to the other; the phenomenon requires us to admit *the existence of a principal discharge in one direction and then several reflex actions backward and forward, each more feeble than the preceding, until the equilibrium is obtained.* All the facts are shown to be in accordance with this hypothesis, and a ready explanation is afforded by it of a number of phenomena, which are to be found in the older works on electricity, but which have until this time remained unexplained." *

The italics are Henry's. Now if this were an isolated passage, it might be nothing more than a lucky guess. But it is not. The conclusion is one at which he arrives after a laborious repetition and serious study of the facts, and he keeps the idea constantly before him when once grasped, and uses it in all the rest of his researches on the subject. The facts studied by Henry do in my opinion support his conclusion, and if I am right in this it follows that he is the original discoverer of the oscillatory character of a spark, although he does not attempt to state its theory. That was first done, and completely done, in 1853, by Sir William Thomson; and the progress of experiment by Feddersen, Helmholtz, Schiller, and others has done nothing but substantiate it.

The writings of Henry have been only quite recently collected and published by the Smithsonian Institution of Washington in accessible form, and accordingly they have been far too much ignored. The two volumes contain a wealth of beautiful experiments clearly recorded, and well repay perusal.

The discovery of the oscillatory character of a Leyden jar discharge may seem a small matter, but it is not. One has only to recall the fact that the oscillators of Hertz are essentially Leyden jars—one has only to use the phrase "electro-magnetic theory of light"—to have some of the momentous issues of this discovery flash before one.

One more extract I must make from that same memoir by Henry,* and it is a most interesting one; it shows how near he was, or might have been, to obtaining some of the results of Hertz; though, if he had obtained them, neither he nor any other experimentalist could possibly have divined their real significance.

It is, after all, the genius of Maxwell and of a few other great theoretical physicists whose names are on every one's lips† which endows the simple induction experiments of Hertz and others with such stupendous importance.

Here is the quotation:

"In extending the researches relative to this part of the investigations, a remarkable result was obtained in regard to the distance at which induction effects are produced by a very small quantity of electricity; a single spark from the prime conductor of a machine, of about an inch long, thrown on to the end of a circuit of wire in an upper room, produced an induction sufficiently powerful to magnetize needles in a parallel circuit of iron placed in the cellar beneath, at a perpendicular distance of 30 feet, with two floors and ceilings, each 14 inches thick, intervening. The author is disposed to adopt the hypothesis of an electrical *plenum* (in other words, of an ether), and from the foregoing experiment it would appear that a single spark is sufficient to disturb perceptibly the electricity of space throughout at least a cube of 400,000 feet of capacity; and when it is considered that the magnetism of the needle is the result of the difference of two actions, it may be further inferred that the diffusion of motion in this case is almost comparable with that of a spark from a flint and steel in the case of light."

Comparable it is, indeed, for we now know it to be the selfsame process.

One immediate consequence and easy proof of the oscillatory character of a Leyden jar discharge is the occurrence of phenomena of sympathetic resonance.

Every one knows that one tuning fork can excite another at a reasonable distance if both are tuned to the same note. Every one knows, also, that a fork can throw a stretched string attached to it into sympathetic vibration if the two are tuned to unison or to some simple harmonic. Both these facts have their electrical analogue. I have not time to go fully into the matter to-night, but I may just mention the two cases which I have myself specially noticed.

A Leyden jar discharge can so excite a similarly timed neighboring Leyden jar circuit as to cause the latter to burst its dielectric if thin and weak enough. The well timed impulses accumulate in the neighboring circuit till they break through a quite perceptible thickness of air.

Put the circuits out of unison by varying the capacity or by including a longer wire in one of them; then, although the added wire be a coil of several turns, well adapted to assist mutual induction as ordinarily understood, the effect will no longer occur.

That is one case, and it is the electrical analogue of one tuning fork exciting another. It is too small at present to show here satisfactorily, for I only recently observed it, but it is exhibited in the library at the back.

The other case, analogous to the excitation of a stretched string of proper length by a tuning fork, I published last year under the name of the experiment of the recoil kick, where a Leyden jar circuit sends waves along a wire connected by one end with it, which waves splash off at the far end with an electrical brush or long spark.

I will show merely one phase of it to-night, and that is the reaction of the impulse accumulated in the wire upon the jar itself, causing it to either overflow or burst. [Sparks of gallon or pint jar made to overflow by wire round room.‡]

The early observations by Franklin on the bursting of Leyden jars, and the extraordinary complexity or multiplicity of the fracture that often results, are most interesting.

His electric experiments as well as Henry's well repay perusal, though of course they belong to the infancy of the subject.

He notes the striking fact that the bursting of a jar is an extra occurrence, it does not replace the ordinary discharge in the proper place, it accompanies it; and we now know that it is precipitated by it, that the spark occurring properly between the knobs sets up such violent surgings that the jar is far more violently strained than by the static charge or mere difference of potentials between its coatings; and if the surgings are at all even roughly properly timed, the jar is bound to either overflow or burst.

Hence a jar should always be made without a lid, and with a lip protruding a carefully considered distance above its coatings; not so far as to fail to act as a safety valve, but far enough to prevent overflow under ordinary and easy circumstances.

And now we come to what is after all the main subject of my discourse this evening, viz., the optical and audible demonstration of the oscillations occurring in the Leyden jar spark. Such a demonstration has, so far as I know, never before been attempted, but if nothing goes wrong we shall easily accomplish it.

And first I will do it audibly. To this end the oscillations must be brought down from their extraordinary frequency of a million or hundred thousand a second to a rate within the limits of human audition. One does it exactly as in the case of the spring—one first increases the flexibility and then one loads it. [Spark from battery of jars and varying sound of same.]

Using the largest battery of jars at our disposal, I take the spark between these two knobs—not a long spark, ¼ inch will be quite sufficient. Notwithstanding the great capacity, the rate of vibration is still far above the limit of audibility, and nothing but the customary crack is heard. I next add inertia to the circuit by including a great coil of wire, and at once the spark changes character, becoming a very shrill but an unmistakable whistle, of a quality approximating to the cry of a bat. Add another coil, and down comes the pace once more, to something like 5,000 per second, or about the highest note of a piano. Again and again I load the circuit with magnetizability, and at last the spark has only 500 vibrations a second, giving the octave, or perhaps the double octave, above the middle C.

One sees clearly why one gets a musical note; the noise of the spark is due to a sudden heating of the air; now if the heat is oscillatory, the sound will be oscillatory too, but both will be an octave above the electric oscillation, if I may so express it, because two heat pulses will accompany every complete electric vibration, the heat production being independent of direction of current.

Having thus got the frequency of oscillation down to so manageable a value, the optical analysis of it presents no difficulty; a simple looking glass waggled in the hand will suffice to spread out the spark into a serrated band, just as can be done with a singing or a sensitive flame—a band, too, of very much the same appearance.

Using an ordinary four-square rotating mirror driven electromagnetically at the rate of some two or three revolutions per second, the band is at the lowest pitch seen to be quite coarsely serrated; and fine serrations can be seen with four revolutions per second in even the shrill whistling sparks.

The only difficulty in seeing these effects is to catch them at the right moment. They are only visible for a minute fraction of a revolution, though the band may appear drawn out to some length. The further away a spark is from the mirror, the more drawn out it is, but also the less chance there is of catching it.

With a single observer it is easy to arrange a contact maker on the axle of the mirror which shall bring on the discharge at the right place in the revolution, and the observer may then conveniently watch for the image in a telescope or opera glass, though at the lower pitches nothing of the kind is necessary.

But to show it to a large audience various plans can be adopted. One is to arrange for several sparks instead of one; another is to multiply images of a single spark by suitably adjusted reflectors, which if they are concave will give magnified images; another is to use several rotating mirrors; and indeed I do use two, one adjusted so as to suit the spectators in the gallery.

But the best plan that has struck me is to combine an intermittent and an oscillatory discharge. Have the circuit in two branches, one of high resistance, so as to give intermittences, the other of ordinary resistance, so as to be oscillatory, and let the mirror analyze every constituent of the intermittent discharge into a serrated band. There will thus be not one spark, but a multitude of successive sparks, close enough together to sound almost like one, separate enough in the rotating mirror to be visible on all sides at once.

But to achieve it one must have great exciting power. In spite of the power of this magnificent Wimshurst machine, it takes some time to charge up our great Leyden battery, and it is tedious waiting for each spark. A Wimshurst does admirably for a single observer, but for a multitude one wants an instrument which shall charge the battery not once only, but many times over, with overflows between, and all in the twinkling of an eye.

To get this I must abandon my friend Mr. Wimshurst, and return to Michael Faraday. In front of the table is a great induction coil; its secondary has the resistance needed to give an intermittent discharge. The quantity it supplies at a single spark will fill our jars to overflowing several times over. The discharge circuit and all its circumstances shall remain unchanged. [Excite jars by coil.]

Running over the gamut with this coil now used as our exciter instead of the Wimshurst machine—everything else remaining exactly as it was—you hear the sparks give the same notes as before, but with a slight rattle in addition, indicating intermittence as well as alternation. Rotate the mirror, and every one should see one or other of the serrated bands of light at nearly every break of the primary current of the coil. [Rotating mirror to analyze sparks.]

The musical sparks which I have now shown you were obtained by me during a special digression* which I made while examining the effect of discharging a Leyden jar round heavy glass or bisulphide of carbon. The rotation of the plane of polarization of light by a steady current, or by a magnetic field of any kind properly disposed with respect to the rays of light, is a very familiar one in this place. Perhaps it is known also that it can be done by a Leyden jar current. But I do not think it is; and the fact seems to me very interesting. It is not exactly new—in fact, as things go now it may be almost called old, for it was investigated six or seven years ago by two most highly skilled French experimenters, Messrs. Bichat and Blondlot.

But it is exceedingly interesting as showing how short a time, how absolutely no time, is needed by heavy glass to throw itself into the suitable rotatory condition. Some observers have thought they had proved that heavy glass requires time to develop the effect, by spinning it between the poles of a magnet and seeing the effect decrease; but their conclusions cannot be right, for the polarized light follows every oscillation in a discharge, the plane of polarization be-

* "Scientific Writings of Joseph Henry," vol. i., p. 201. Published by the Smithsonian Institution, Washington, 1886.

* *Loc. cit.*, p. 204.

† And of one whose name is not yet on everybody's lips, but whose profound researches into electro-magnetic waves have penetrated further than anybody yet understands into the depths of the subject, and whose papers have very likely contributed largely to the theoretical inspiration of Hertz—I mean that powerful mathematical physicist, Mr. Oliver Heaviside.

‡ During the course of this experiment, the gilt paper on the wall was observed by the audience to be sparkling, every gilt patch over a certain area discharging into the next, after the manner of a spangled jar. It was probably due to some kind of sympathetic resonance. Electricity splashes about in conductors in a surprising way everywhere in the neighborhood of a discharge. For instance, a telescope in the hand of one of the audience was reported afterward to be giving off little sparks at every discharge of the jar. Everything which happens to have a period of electric oscillation corresponding to some harmonic of the main oscillation of a discharge is liable to behave in this way. When light falls on an opaque surface, it is quenched. What the audience saw was probably the result of waves of electrical radiation being quenched by the walls of the room, and generating electrical currents in the act. It is these electric surgings which render such severe caution necessary in the erection of lightning conductors. This explanation is merely tentative. I have had no time to investigate the matter locally.

* Most likely it was a conversation which I had with Sir Wm. Thomson, at Christmas, which caused me to see the interest of getting slow oscillations. My attention has mainly been directed to getting them quick.

ing waved to and fro as often as 70,000 times a second in my own observation.

Very few persons in the world have seen the effect. In fact, I doubt if any one had seen it a month ago except Messrs. Bichat and Blondlot. But I hope to make it visible to most persons here, though I hardly hope to make it visible to all.

Returning to the Wimshurst machine as exciter, I pass a discharge round the spiral of wire inclosing this long tube of CS_2, and the analyzing Nicol being turned to darkness, there may be seen a faint—by those close to not so faint, but a very momentary—restoration of light on the screen at every spark. [CS_2 tube experiment on screen.]

Now I say that this light restoration is also oscillatory. One way of proving this fact is to insert a biquartz between the Nicols. With a steady current it constitutes a sensitive detector of rotation, its sensitive tint turning green on one side and red on the other. But with this oscillatory current a biquartz does absolutely nothing. [Biquartz.]

That is one proof. Another is that rotating the analyzer either way weakens the extra brightening of the field, and weakens it equally either way

But the most convincing proof is to reflect the light coming through the tube upon our rotating mirror, and to look now, not at the spark, or not only at the spark, but at the faint band into which the last residue of light coming through polarizer and tube and analyzer is drawn out. [Analyze the light in rotating mirror.]

At every discharge this faint streak brightens in places into a beaded band; these are the oscillations of the polarized light; and when examined side by side, they are as absolutely synchronous with the oscillations of the spark itself as can be perceived.

Out of a multitude of phenomena connected with the Leyden jar discharge I have selected a few only to present to you here this evening. Many more might have been shown, and great numbers more are not at present adapted for presentation to an audience, being only visible with difficulty and close to.

An old and trite subject is seen to have in the light of theory an unexpected charm and brilliancy. So it is with a great number of other old familiar facts at the present time.

The present is an epoch of astounding activity in physical science. Progress is a thing of months and weeks, almost of days. The long line of isolated ripples of past discovery seem blending into a mighty wave, on the crest of which one begins to discern some oncoming magnificent generalization. The suspense is becoming feverish, at times almost painful. One feels like a boy who has been long strumming on the silent keyboard of a deserted organ, into the chest of which an unseen power begins to blow a vivifying breath. Astonished, he now finds that the touch of a finger elicits a responsive note, and he hesitates, half delighted, half affrighted, lest he be deafened by the chords which it would seem he can now summon forth almost at will.

[Continued from SUPPLEMENT, No. 694, page 11082.]

ARC LAMPS AND THEIR MECHANISM.*

By Prof. SILVANUS P. THOMPSON, D.Sc., M.I.E.E.

WE are now prepared to enter upon the mechanical devices which have been suggested for the feeding mechanism of lamps. These are so varied, and run so curiously into one another, that no classification of them is entirely satisfactory. In a very large class of lamps there is a train of wheel work, usually driven by the weight of the descending carbon rods, the last member of the train being controlled through a detent or brake, by the electromagnet that is responsible for the feeding of the lamp. Most, but not all, of these lamps have a rack upon the upper carbon rod to drive the train. But the rack lamps differ greatly among themselves. Again, there is another class of lamps in which the upper carbon rod is smooth, but is assisted and controlled in its descent by a clutch or clamp, the clutch or clamp being in turn controlled by the feeding electromagnet. But there are also rack lamps in which a clutch or clamp is applied, not to the rod itself, but to a wheel driven by the descending rack. There are, however, certain main features of classification about which there need be no ambiguity.

FEED MOTIONS.

[*i.*] *Rack and Train* controlled by—
- (*a.*) Star wheel and detent [Staite, 18,783[17]; Foucault-Duboscq; Serrin, 653[55]].
- (*b.*) Fly and detent [Staite, 1848; Duboscq, 1855].
- (*c.*) Brake wheel and brake [Chapman, 739[46]; Crompton, 346[67]].
- (*d.*) Escapement with pendulum or balance and detent [Siemens, 4,949[76]; Harding, 3,166[51]; Waterhouse, 5,185[51]].
- (*e.*) Escapement and paddle [Waterhouse, 5,185[51]].
- (*f.*) Governor with detent or moderator [Waterhouse, 5,185[51]].
- (*g.*) Magnetic brake wheel or detent [Brockie, 1,713[38]; Harling, 3,473[51]].
- (*h.*) Liquid brake [Hopkinson, 153[51]].

[*ii.*] *Clutch or Clamp on Rod*—
- (*a.*) Tilting ring, tilting eyelet, etc. [Slater and Watson, 212[50]; Brush, 2,008[75]; Lumley, 1,249[23]; Lever, 2,092[64]; Thomson-Houston; Waterhouse, etc.]
- (*b.*) Split cone gripped by fork [Slater and Watson, 212[50]].
- (*c.*) Split nozzle forced into cone mouthpiece [Burgin, 4,820[51]].
- (*d.*) Split tube held together by oblique levers [Rogers, 3,236[55]].
- (*e.*) Gripping springs at side [Lever, 3,599[51]; Munro, 1,626[62]].
- (*f.*) Gripping fingers [Roberts, 14,198[13]; Joel, 5,157[79]; "devil's claws," Harding, 3,166[51]].
- (*g.*) Washer jambed by ball bearing [Young, 1,689[23]; or roller, Newton, 4,559[51]].
- (*h.*) Tilting clamp or nipping clamp [Common, 626[67]].
- (*j.*) Nipping lever [Grimstone, 1,670[51]; Mondos, 5,490[51]].
- (*k.*) Scissors lever [Joel, 3,970[24]; Jarman, 563[51]; Gerard-Lescuyer, 2,092[64]].
- (*l.*) Spiral spring surrounding rod (Keilhotz, 1886; Thouvenot, 1887].
- (*m.*) Forward-pointing springs (lobster trap) [Newton, 1,623[33]; Clark-Bowman, 1,182[51]; Holmes, 769[66]; Hawkes, 157[70]].

[*iii.*] *Clutch Wheel or Brake Wheel*—
- (*a.*) Nipping lever outside brake wheel [Gramme, 1861; Common and Joel, 1,040[51]; Brockie, 4,419[22]].
- (*b.*) Nipping lever inside rim of wheel [Union Co., 392[48]; Brockie, 4,419[22]].
- (*c.*) Elastic band brake [Statter, 2,985[51]].
- (*d.*) Elastic internal ring brake [Siemens, 6,987[67]; Fein, 1888].
- (*e.*) Wheel lifted against brake or detent [Burgin, 4,820[51]].
- (*f.*) Brake wheel lifted upon brake lever [Gumpel, 253[51]; Crompton-Crabb, 2,539[87]].
- (*g.*) Friction pad on rim of wheel [Abdank, 1882].

[*iv.*] *Screw Motion*—
- (*a.*) Screw worked by weight of upper rod [Hopkinson and Muirhead, 153[51]; Cance, 3,976[51]; Akester, 2,419[27]]
- (*b.*) Screw worked by motor [Tchikoleff, 1874].
- (*c.*) Screw worked by step feed [Street-Maquaire, 9,666[86]].
- (*d.*) Screw worked by vibrated wheel [Siemens, 6,987[67]].

[*v.*] *Cord and Pulley Motions*—
- (*a.*) Cord and pulley to core of solenoid [Archereau, 1848; Jaspar, 83[79]].
- (*b.*) Cord and pulley connecting carbons, with long-travel solenoid [Pilsen lamp, 1,397[66]; Doubrava, 1,033[66]].
- (*c.*) Cord gripped by controlling cam [Harding, 4,590[79]].
- (*d.*) Cord and pulley for differential feed [Weston, 1883; Kennedy, 1888].

[*vi.*] *Step-by-Step Motions*—
- (*a.*) Step detent worked by electromagnet [Deleuil, 1856; Brockie, 898[38]; Gatehouse and Kempe, 2,56[69]; Kennedy, 5,524[51]].

[*vii.*] *Magnetic Clamps and Clutches*—
- (*a.*) Tilting magnet clutch on rod [Roberts, 14,198[13]; Gulcher, 2,038[51]].
- (*b.*) Magnetic clamp on brake wheel [Harling and Hartmann, 3,473[51]; Hardt, 1886].

[*viii.*] *Electric Motor Action*—
- (*a.*) Motor screws carbon up or down [Tchikoleff, 1874, and 2,198[51]; Maquaire, 1889].
- (*b.*) Winds up with cord or rack [Andrews, 2,321[79]; Andre, 2,764[83]; Bousfield, 523[79]; Breguet, 1879].
- (*c.*) Motor itself controlled by shunt magnet [Thomson-Houston, 315[50]].
- (*d.*) Motor with copper damper [Thury, 1888].

[*ix.*] *Hydrostatic and Pneumatic Action*—
- (*a.*) Carbons controlled by admission of liquid or gas [Lacassagne and Thiers, 2,456[55]; Hopkinson, 3,509[80]; Leibold, 1886; Sedlaczek, 1883].

[*x.*] *Vibrating Feeds*—
- (*a.*) Make and brake lever vibrate forward-pointing springs [Newton, 1,623[33]; Pieper, 4,647[74]; Holmes, 769[66]].
- (*b.*) Make and brake lever actuates escapement [Harding, 3,166[51]].
- (*c.*) Make and brake lever actuates detent on train [Gramme, 1880].
- (*d.*) Make and brake lever hammers rod through clutch [Letang, 5,509[87]].
- (*e.*) Make and brake lever works internal clutch wheel feed [Fein, 1888].
- (*f.*) Make and brake lever drives pallet and screw feed [Siemens (Alteneck), 1885].

[*xi.*] *Periodic Feeds*—
- (*a.*) Periodic drop of upper carbon and lift through definite range [Brockie, 898[38] and 1,713[38]].
- (*b.*) Periodic currents to magnet sent through second wire [Andre, 4,948[51]].

[*xii.*] *Continuous Feeds*—
- (*a.*) Clockwork step feed, length of stroke varied by magnet [Brockie, 898[38]].
- (*b.*) Pendulum or governor, having rate varied by magnet [Waterhouse, 5,185[51]].
- (*c.*) Rack train controlled by magnetic retardation on copper wheel [Niaudet, 1878].

[*xiii.*] *Hammering Feeds*—
- (*a.*) Rod driven through clutch by vibrating hammer [Letang, 5,509[87]; Capito and Hardt, 1887].
- (*b.*) Ditto, by tilting lever [Jolin, 2,570[62]].
- (*c.*) Ditto, by magnetic pile driver on rod [King, 1888].

Outside the classification adopted above are several well-marked features of mechanism; one of these is the *parallelogram motion*. A typical case of this is afforded by the well-known Serrin [653[55]] lamp (Fig. 5). A jointed parallelogram is constituted by the pieces which meet at A B C D. The side, A C, is fixed, being part of the frame, while the levers, A B C D, rise and fall through a small angle, carrying with them the upright, B D. To this upright is fastened a sleeve, through which the lower carbon holder passes. This moving parallelogram is held up by a spring, *s*. When the electromagnet, E (in main circuit), attracts its armature, *a*, the parallelogram, and with it the lower carbon, sinks, and so the arc is struck. At the same instant a projecting triangular detent, U, engages against the star wheel of the driven train and locks it, so that the upper carbon cannot descend. As the carbons are consumed the current is weakened, owing to the increasing resistance of the lengthening arc, and the electromagnet lessens its attraction; consequently the parallelogram gradually rises, until a moment occurs when the detent ceases to lock the star wheel. The upper carbon holder is now free to descend a little, driving the train of wheels, shortening the arc, restoring the normal current, and so again causing the electromagnet to pull down the parallelogram and lock the wheels. Parallelogram motions are to be found also in Burgin's lamp [4,820[51]] and in Siemens' pendulum lamp [4,949[76]].

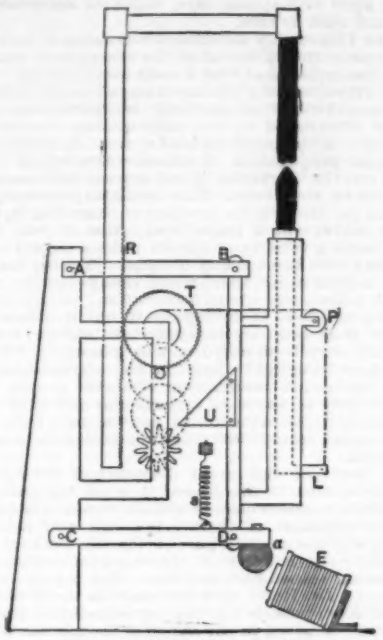


FIG. 5.—SERRIN'S LAMP.

Another characteristic mechanism is the *seesaw* lever. Fig. 6 shows the form used in the Brockie-Pell lamp [12,081[86]]. The earliest use of the seesaw, attracted at opposite ends by series and shunt magnets, respectively, occurs in the lamp of Lacassagne and Thiers [2,456[55]]; while modern examples are Weston's lamp, the Thomson-Houston lamp (Fig. 14), and Fein's lamp of 1883. [Also Moffat and Chichester, 3,441[51]; and Chadburn, 2,755[51], where the seesaw works a clutch.] A compact modification of the seesaw me-

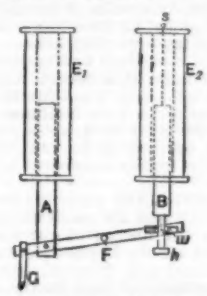


FIG. 6.—SEESAW OF BROCKIE-PELL LAMP.

chanism occurs in one form of Weston's lamp, and again in Kennedy's lamp of 1888, Fig. 10. Here the lever is replaced by a pulley over which passes a cord or ribbon of metal. In this lamp the shunt solenoid is furnished with a plunger core, while the series solenoid on the left has a plunger and an external iron mantle to increase its power. The smaller pulley communicates the motion to a clutch. The advantage of the seesaw, and of its pulley equivalent, is that such an arrangement enables the lamp to be used as either a constant potential lamp or as a constant current lamp. In the former case the shunt coil holds up its end, while the seesaw is operated by the variations of the current in the series coil. In the latter case the actions are the inverse of this.

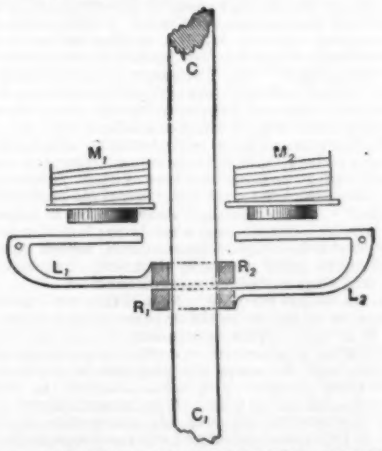


FIG. 7.—SLATER AND WATSON'S CLUTCH.

The *rack-train* mechanism which forms the first class in the preceding list presents two special points. As this mechanism is in itself non-retractile, and can only propel the carbons forward, it cannot be used with non-homogeneous carbons of second quality, unless special provision is made in the striking mechanism of the lamp for a retractile movement. There is nothing retractile, for example, about the Breguet lamp (Fig. 3), but there is about the Serrin (Fig. 5), for the lower carbon holder (which descends to strike the arc) is

* A lecture recently delivered before the Society of Arts, London. From the *Journal* of the Society.

never held tight down by the electromagnet, but takes up a position of equilibrium. The other point is that in these rack-train lamps some device is requisite to lock the train at the instant of striking, otherwise the feed motion would neutralize the strike motion. In some lamps [Breguet, Sellon, etc.] there is a mechanical connection from the striking part to lock the feed. In some other lamps the action is performed electrically. In the De Puydt lamp (Fig. 24) a pin on the train frame engages with a forked connecting piece from the feeding lever.

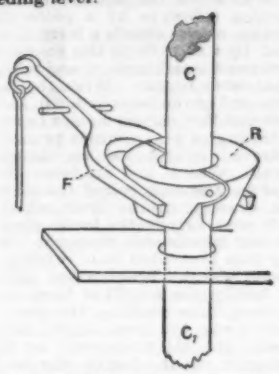


FIG. 8.—SLATER AND WATSON'S SPLIT CONE.

A characteristic arrangement, applicable to rack-train lamps, is that in which, for the purpose of striking the arc, the whole train mounted in its framework, together with the rack and the upper carbon rod, is bodily lifted by the use of an electromagnet in the main circuit. [Crompton, 346[93]; Fyfe and Main, Hochhausen, Gumpel, Berjot, Wood, Maxim, etc.] More neat is the method of rocking the train bodily around the axis of one of the wheels of the train. [Brockie, 2,370[93]; and De Puydt, Fig. 23].

Passing from the *rack-train* lamps to the *clutch* lamps, it may be noted how much ingenuity has been

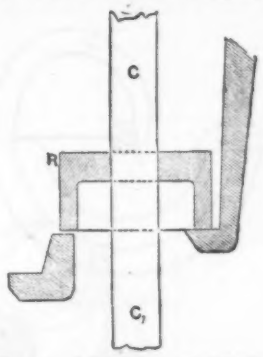


FIG. 9.—LEVER'S CLUTCH.

expended in attempting to find a form of clutch which will prove reliable under all conditions of working. Two of the very earliest forms of clutch mechanism are worth recalling in this connection. These are both due to Slater and Watson [212[92]]. The first (Fig. 7) shows a carbon rod sliding through a couple of rings or eyelets, which are tilted by the attraction of an electromagnet to grip and raise the rod. In the second (Fig. 8) the clutch consists of a split conical washer, the two halves of which are hinged together. These are compressed by the rising of a fork, which nips and raises them. The tilting ring introduced by Brush is too well known to need comment. Lever's modification

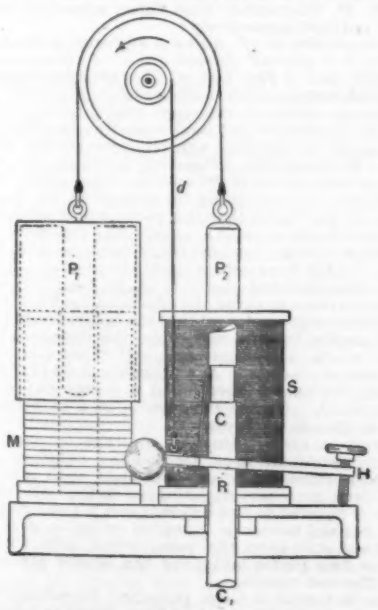


FIG. 10.—KENNEDY'S LAMP.

of the tilting ring is shown in Fig. 9, the rim below the ring causing the thrust to act more obliquely at first, and allowing the clutch to work even when the aperture is considerably worn. In the latest forms of this clutch, the ring has a tail piece which is hinged to the frame of the lamp. Another successful form of tilting clutch is shown in Fig. 10, which represents the mechanism of Kennedy's lamp. The clutch has a long tail, provided with an adjusting screw to regulate its position, and bears against the carbon rod by a slender spring, *s*, above. It is worked by a thin cord, *d*, running over a pulley in connection with the differential arrangement of shunt, S, and series, M, solenoids described above. A clutch provided with a spring that bears against the carbon rod is also found in the Clark-Bowman lamp [1,182[93]], the feeding in this case being accomplished while the clutch is held up, by giving to it a mechanical vibration. In the Kennedy lamp the spring on the clutch also serves the purpose of finally arresting the descent of the carbon holder, catching on a groove cut around its upper end when the carbon pencil is all consumed. Another simple clutch with spring mounting, worked by the mutual repulsion between two similarly magnetized cores, has been devised by Swinburne [11,893[86]]. Clutches of the knee lever type have been devised by Lorrain [183[93]] and Joel [3,970[86]]. The more complex "scissors joint" levers, used in one of Joel's lamps, are drawn in Fig. 11. Their

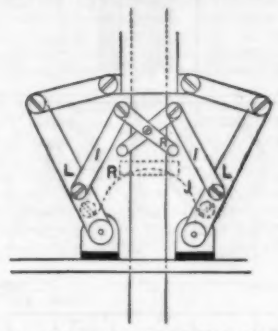


FIG. 11.—JOEL'S SCISSORS JOINT.

action is obvious, as their upper end is raised by the upward pull of the electromagnet or solenoid they grip, and raise the carbon rod, and they relax their grip on being lowered to feed the arc. Very similar devices are found in Gerard's and Jarman's lamps. An ingenious species of clutch, by F. M. Newton [4,559[91]], is illustrated in Fig. 12. This consists of a ball bearing or roller bearing, which on the raising of the collar in which it lies jams against the carbon rod and raises it. Another extremely simple clutch [Lorrain, 630[93]] con-

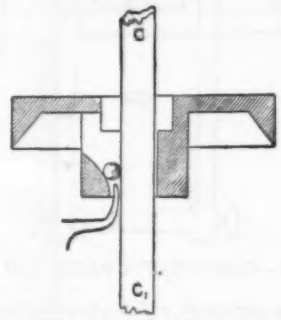


FIG. 12.—NEWTON'S ROLLER CLUTCH.

sists of a plunger working horizontally through a solenoid, pressed sideways by a spiral spring against the carbon rod; the pressure of this is taken off, when feeding is required, by the pull due to the current in the solenoid, which is connected as a shunt. Rogers' [3,236[92]] simple and very efficient form of clutch consists of a split tube, the parts of which are connected together by a pair of oblique links, making a sort of parallel motion. This form is shown in Fig. 13.

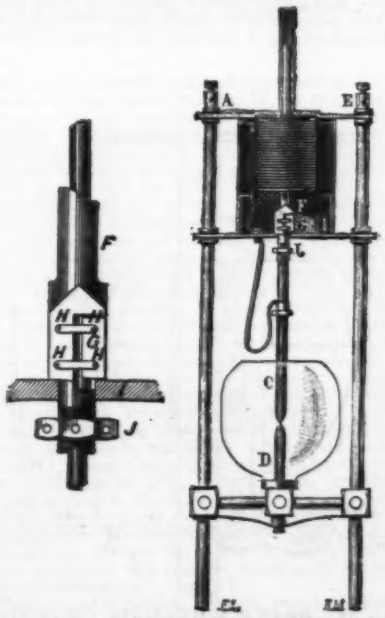


FIG. 13.—ROGERS' CLUTCH.

In the Thomson-Houston lamps so widely used in the United States, a peculiar clutch is employed, consisting of a pair of levers jointed together, one of them being perforated with an eyelet through which the carbon rod passes. The mechanism of this lamp, shown in Fig. 14, consists of a seesaw lever, L L, pivoted at O, and provided with a long tail, T, the motion of which is moderated by an air dash pot. Below is an electromagnet, M, in the main circuit, and above is a second, S, which is connected as a shunt. The pole pieces of both are of conoidal shape, protruding through apertures in the armatures *a a* and *b b*, to give longer range of pull. The lower and upper arms of the clutch, marked R and K, close together when the tail, T, rises, gripping the carbon rod, C, and raising it. From this diagram, which also shows the electric connections, it appears that the current entering the lamp through an insulated terminal at +P flows first round M, and

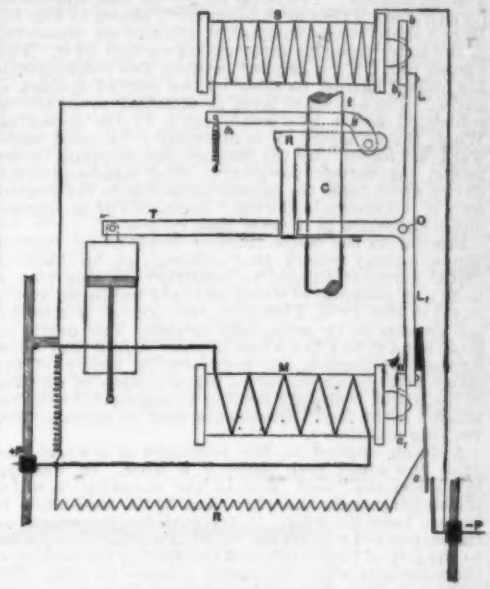


FIG. 14.—MECHANISM OF THOMSON-HOUSTON LAMP.

then goes to the frame of the lamp. Thence it divides, the main current finding its way to the upper carbon holder, and so through the arc to the lower carbon, whence it returns (by a route not shown) to the insulated negative terminal, −P. A smaller portion of the current flows up round the shunt electromagnet to −P. The arc is struck by the preponderating main circuit current in M attracting the lever end of the seesaw lever, and raising the clutch.

The feeding is accomplished by the preponderating pull of the shunt magnet as the arc increases in length. The resistance wire across from +P to *c* constitutes a cut-out circuit, which is brought into operation by the augmented current in S on any failure of the main current. The small coil connected across from +P to the lamp frame is a mere adjustment to regulate once for all the power of the series coil, *m*, relatively to that of the shunt coil, S.

It will be noted that in the operation of all these clutch actions there are really four periods. In striking the arc there is a first stage of affairs, where the clutch rises sufficiently to grip the carbon rod, immediately followed by a second stage, during which it rises still further, and lifts the carbon rod, so striking the arc. During the third stage or period the clutch still retains its grip, but as the arc burns away the clutch is gradually lowered. This is due, in constant potential lamps, to the weakening of the main current; in constant current lamps, to the increasing opposing action of the shunt. The fourth stage is reached when the arc has burned away so far that the clutch has been lowered to the point where it begins to relax its grip, and now feeding commences, the rod slipping a little, but the clutch simultaneously rises a little, and grips again, again to descend.

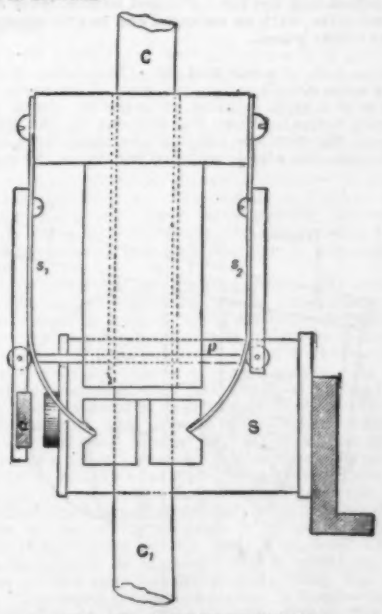


FIG. 15.—HOLMES' FEED.

In a well-adjusted clutch lamp the clutch is indeed incessantly rising and falling through minute distances about the critical position. A bad clutch, or one that is deranged by dirt, will overfeed, and then rise too far, feeding spasmodically. Theoretically, all these clutches possess the retractile property so useful in keeping a steady arc when the carbons are of indifferent quality.

But it is obvious that their perfection of action is impaired by dirt, dust, and inequalities in the surface of the carbon rod due to wear and tear.

Clutches of the class termed "forward feeding" belong to a different category, as they have, for the most part, no retractile power. In Newton's form [1,623[87]] a piece of steel curry comb, bent so as to form a sort of lobster trap, encircles the carbon rod, and forces it gradually forward when mechanical vibrations are imparted to it by a lever, working with a vibration on the plan of the well known electric-bell vibrator, from the armature of a shunt magnet. The latest variety of this species of forward feed is that of Holmes [769[86]], shown in Fig. 15. Here a shunt electro-magnet, S, attracts an armature, *a*, the latter being mounted upon a vertical lever. The carbon rod, C C_1, is gripped between two blocks which are pressed against its sides by two curved springs, s_1 and s_2. The armature lever is attached to s_1, and is connected across by a small rod, *p*, to the spring, s_2. When the armature, *a*, is alternately vibrated backward and forward by the magnet, the gripping blocks propel the carbon downward. The make-and-break device which turns the current off and on in the magnet coils is not shown in the cut. It consists of an ingenious modification of Holmes' snap switch.

Passing to the *clutch wheel* or *brake wheel* type of lamps, we may remark that although so far back as 1861 Gramme attempted to construct on this plan a lamp (the existence of which was only published to the world in 1888 by M. Fontaine), this species of mechanism appears to be essentially British. The device of applying a clutch to a wheel in order to feed that wheel forward by degrees, the reciprocating motion of the clutch lever being converted into a motion of rotation of the wheel, is already familiar to engineers in the so-called "silent feed" movements used in spinning and weaving machinery.

A clutch applied to the periphery of a wheel first grips the wheel, then turns it a little. In weaving machinery the "feed" acts in the direction in which the clutch propels the wheel, but in its application to the arc lamp the action is reversed, for the weight of the carbon rod propels the wheel in a direction opposed to the grip of the clutch, and the feeding takes place at those instants when the clutch releases its grip. The matter is best studied by reference to actual cases. Fig. 16 depicts the clutch wheel of Common and Joel.

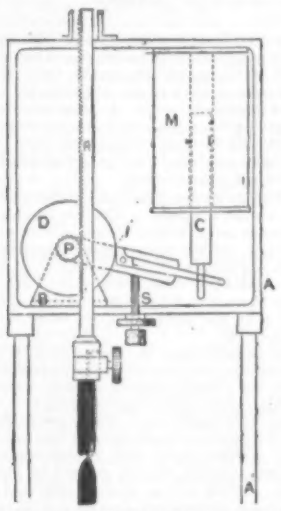


FIG. 16.—COMMON AND JOEL'S CLUTCH WHEEL.

The descending rack, R, drives the wheel, D, by means of the pivot, P. Pivoted loosely around the same arbor is a heavy lever, which is prevented by a stop, S, from descending too far. Pivoted to this lever at L is a second lever, with an enlarged end to grip against the surface of the wheel.

The tail of this nipping lever is attached by a pin to the iron core of a solenoid, M. (The latter is wound with a main circuit coil only if wanted for use in parallel, or with a main coil and an opposing shunt coil if for use in series.) When the current in the solenoid draws up the core, the nipping lever first turns, around L and grips the wheel; any further rise of the core will

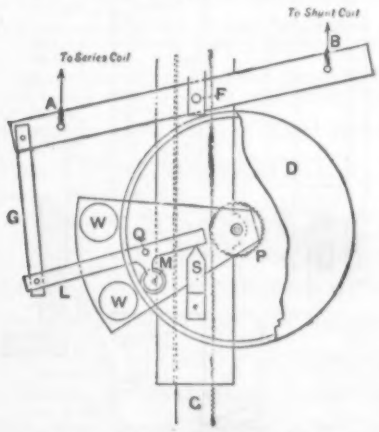


FIG. 17.—BROCKIE-PELL LAMP.

cause the two levers and the wheel to turn bodily together round the arbor, and this second action causes the arc to be struck. Then begins the third period of action, during which the levers slowly descend until the weight lever touches S. Then the fourth period begins; any further descent of the core causing the nipping lever to release its grip, and allowing feeding to take place, followed by a slight rise in the core and renewal of grip.

A form of clutch wheel lamp which has become deservedly popular of late is that known as the Brockie-Pell [4,419[87] and 12,681[88]]. The seesaw belonging to this lamp was shown in Fig. 6. The descending carbon rod drives a wheel having a strong projecting rim,

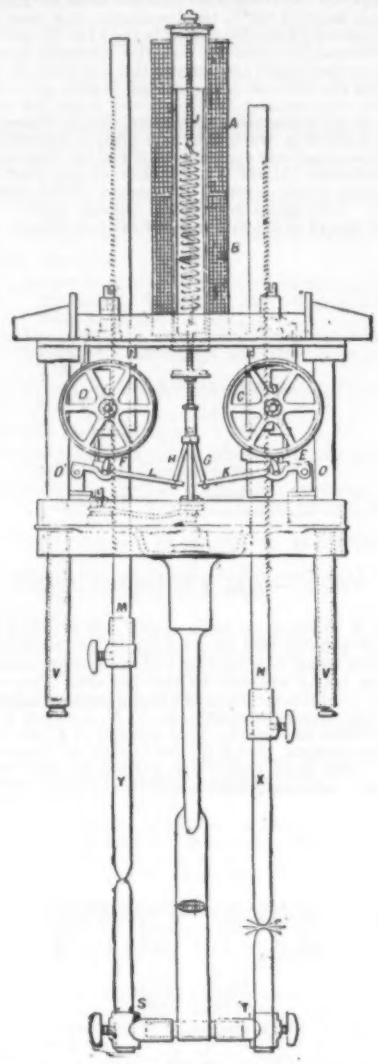


FIG. 18.—CROMPTON-CRABB D D LAMP

at the inner surface of which a brake is applied. This consists of a small leather pad, *m*, fastened to a short arm which projects downward from the nipping lever, L, pivoted at Q to a sector-shaped lever behind, which carries two weights, W W, to increase its downward-bearing power. This weight-lever is loosely pivoted on the arbor, P, and turns solidly with the wheel when the brake is applied. There is a stop, S, to limit the descent, but it is in this case applied to the tail of the nipping lever. A connecting link, E, joins the nipping lever, L, to the seesaw. The internal position of the brake appears to have two advantages, namely, longer leverage around the fixed pin, making the feed more sensitive, and giving greater protection from dust and dirt. One peculiarity of the Brockie-Pell lamp is seen by reference to Fig. 6, namely, the device by which the

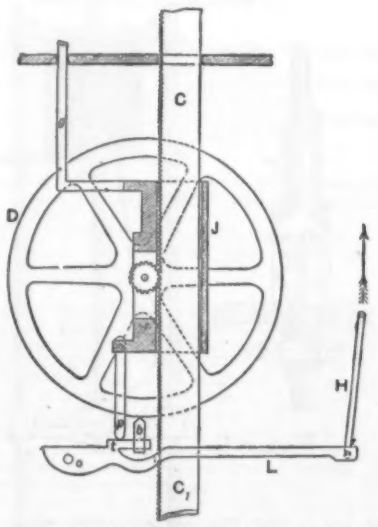


FIG. 19.—BRAKE WHEEL OF CROMPTON-CRABB LAMP.

core, B, of the shunt coil is allowed a certain travel upward before it pulls at the seesaw lever, its thinner part passing freely through a swiveled washer, *w*, on the seesaw. But the washer is of iron and the core has an enlarged head, *h*. These adhere by magnetic attraction when the shunt coil comes into operation.

Another very successful form of lamp is the Crompton-Crabb "double differential" [2,539[83]] shown as a whole in Fig. 18 and in detail in Fig. 19. In the lamp shown in Fig. 18 there are two carbon rods, M and N, of which N comes first into operation, afterward changing over. On each carbon rod is cut a rack which drives a brake wheel or, rather, a pair of brake wheels, one behind the other on the same pinion. The arbor bearing is not, as in the two preceding lamps, fixed in the frame of the lamp, but passes through a short sleeve or jockey, which, when the wheel is free to turn, can slide up or down on the carbon rod, but is prevented from turning sideways by a guide pin, *g*, above. Below the brake wheels stands a lever, L, pivoted at *o*, and attached by a link, H, to the solenoid overhead. This lever carries a small table, *t*, and a brake piece, *b*, faced with phosphor bronze. When the lamp is out of action the free end of the lever is down, and the weight of the wheels and the carbon holder bears down upon the table, *t*, through a pin, *p*, which projects down from the jockey sleeve. In this position the wheels do not touch the brake piece, *b*, and are free. When the current is turned on, the main coil of the solenoid attracts its core, first drawing up the lever, which, turning on its pivot as it rises, brings the brake piece against the rim of the brake wheels and clamps it. Secondly, the wheels being thus prevented from turning, any further rise of the lever lifts the brake wheel, jockey, and carbon holder bodily (the weight of them all resting on the brake piece), thus striking the arc. Thirdly, as the arc burns away, the lever again descends, until, fourthly, when the tail piece rests on the table and takes the weight off the brake, the feeding begins. There are many other points of interest about this lamp which cannot here be discussed.

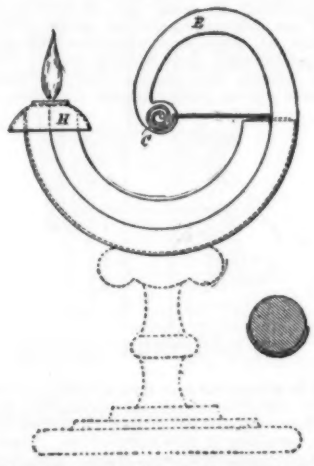
Other forms of brake wheel have been used with success, notably an elastic band brake, resembling Appold's well known device, applied outside a smooth wheel, in Statter's lamp [2,985[88]].

(To be continued.)

CANDLE LAMP.

By J. MARTIN, Kew, near Melbourne, Victoria.

THE ingenious candlestick shown in the illustration is designed for use with a special form of curved candle. The latter lies in a semi-cylindrical curved groove and is fed to the point of combustion as fast as burned, by



means of the spring attached to the origin of the spiral frame. The graceful shape and mechanical efficiency of the plan are both worthy of note. The sectional view shows the candle lying in the case.

POLARIZED LIGHT.

AT a recent meeting of the Physical Society, London, Dr. S. P. Thompson read three notes on polarized light, entitled respectively:

"*The Structure of Natural Diffraction Gratings of Quartz*," "*Ahrens' Modification of Delazenne's Polarizer*, and "*The Use of Two Quarter-Wave Plates in Combination with a Stationary Polarizer.*" Two microscope slides of iridescent quartz (prepared by the late Mr. Darker) which have recently come into the possession of the author, exhibit remarkable peculiarities. Both act like diffraction gratings, one as if the rulings were about 12,000 and the other about 26,000 to the inch. On examining the specimens by the microscope, it was found that the parts which exhibited the grating effects showed a spindle-like structure, and by micrometer measurements the dimensions of the spindle-shaped bodies were determined to be from $\frac{1}{10000}$ in. to $\frac{1}{15000}$ in. in diameter and $\frac{1}{100}$ in. to $\frac{1}{150}$ in. long. These were much too large to cause the effects noticed, but on closer examination it was found that the bodies were crossed at right angles by fine markings, the distances between which are in close accordance with those deduced from the spectra produced. As a probable cause of the phenomenon, the author mentioned a recent paper by Professor Judd, "On the Production of a Lamellar Structure in Quartz by Pressure," and suggested the possibility of making diffraction gratings by such means. Ahrens' modification of Delazenne's polarizer consists of a total reflection prism combined with glass plates and black glass mirror, arranged so that the polarized beam is parallel to the original one. The combination of plates and mirror is adopted so as to give enough light and still keep the polarization sufficiently good. One or two plates laid over the mirror are found to give the best results.

The fact that a beam polarized by reflection is not coincident with the original beam renders it inconvenient, if not impossible, to rotate the polarizer, and to overcome this defect the author has arranged two quarter-wave plates, one of which may be rotated. The first plate circularly polarizes the plane polarized beam, and the second (or rotating one) replane polarizes it in any desired plane. Objects were shown on the screen to illustrate the degree of perfection attainable by using the new polarizer in combination with the two quarter-wave plates.

A SPECTROSCOPE WITH FLUID PRISM.

By A. F. MILLER.

SOME who have constructed and experimented with the small spectroscope described in a former issue (No. 672) of this journal may desire to possess an instrument of greater efficiency as regards both dispersive and defining powers, but yet may be unwilling to have recourse to the optician for a dense fluid prism and set of achromatic lenses, and, further, may not have mechanical facilities for constructing the rather elaborate table spectroscope, details of which appeared in No. 651.

For the benefit of such, a very excellent form of instrument will be described, which can be made from materials of the most inexpensive character, by the aid of the simplest tools and at the cost of but little time; and yet is capable of giving an angular dispersion greater than that under ordinary circumstances attainable by the use of almost any single dense fluid prism, and good definition throughout the entire length of the visible spectrum.

This spectroscope is provided with a *fluid* prism, *i. e.*, a vessel of prismatic form with glass sides, so made as to contain a liquid of very high refractive index—by preference for many reasons carbon disulphide being the fluid selected.

Since, in the ordinary use of the prism for experiments in refraction and dispersion, but two faces are employed, it will suffice that two sides of our spectroscope prism shall possess the quality of transparency. A small vessel of tin plate having the form represented in Fig. 1 is, therefore, to be made or ordered of a tin worker; its triangular surfaces are of equilateral form and its rectangular ones squares; two inches on the sides will be a very convenient dimension. Care should chiefly be observed to have the lines bounding the square faces *strictly parallel*, as here a very slight deviation from accuracy will tend to cause distortion of the spectrum. Two of the square faces are perforated with circular apertures of one inch diameter, as shown at H' H'', the other face remaining unapertured. One of the triangular sides must also have a ¼ inch hole, round the outside of which is soldered, as a neck, a ½ inch length of tin or brass tubing, F, with ¼ inch internal aperture destined to be stopped by a cork. The tin vessel thus prepared should be cleaned from every trace of grease, resin, and soldering flux, by washing with a dilute solution of caustic potassa and rinsing with clean rain water. When dried it is to be dead-blacked *on the inside only* by means of a thin solution of glue in ink, applied warm through the side apertures by the aid of a camel's hair pencil or a little swab of cotton batting tied on a wire.

The transparent sides, one of which is represented *in situ* at G G', may be cut from almost any refuse bit of good mirror plate glass, which, however, should not greatly exceed $\frac{1}{16}$ inch in thickness. The dimensions of these little glass squares will, of course, conform to the sides of the tin vessel. The rough cut or cleavage caused by the diamond should be removed by holding the edges upon a well wetted and slowly revolving grindstone, or by a file supplied with spirit of turpentine having camphor in solution; if bevels are produced, a better appearance results. After being cleaned from greasiness by rinsing in the caustic potassa solution, followed by rinsing with clear rain water, the sides are ready for attachment one over each of the apertures, H' H'', of the tin form, which is thus converted into a veritable hollow prism. The medium for thus cementing them is acetic glue, and as this must be carefully made to secure the best result, simple directions for its preparation are given: A small quantity of fine white glue should be placed in a china cup and steeped in water just sufficient to cover it; when the water is absorbed, a moderate heat is applied till the mass becomes fluid, on which enough strong acetic acid is added to reduce the mixture to the consistency of thick cream, a drop or two of glycerine being also stirred in. This glue is applied in a fairly thick coating over one side of the tin vessel, previously made hot to promote adhesion; one of the glass sides, also previously heated, is now dexterously applied thereon, so as to avoid the squeezing out of any glue upon the circle of clear glass covering the central aperture. It is then advisable to place the prism, glass side downward, upon a smooth cloth-covered surface, and press it under a moderate weight for forty-eight hours, by which time the glue will have sufficiently hardened to permit of the second side being secured by a repetition of the same operation. Of course, both sides may, if preferred, be fixed on at once, but as an intermediate heating of the tin is necessary, there is some danger of displacing one glass while attaching the other. After the lapse of a few days the prism may be filled with the best carbon disulphide, and the neck, F, closed with a sound cork pushed in level with the top of the tube and coated with acetic glue. A small air space should be left to allow for expansion. Proper care having been exercised in the cementing, scarcely a trace of evaporation will be perceptible, even after long periods of time. The prism should lastly be enveloped in dead black paper, wherein circular apertures have been cut to correspond with H' H'', and just a shade smaller than these.

The stand best adapted for a prism of this kind appears, partly in section, at Fig. 2. Its circular table, T' T'', four inches in diameter, is cut by the aid of a compass saw from a piece of dry ¼ inch pine, the edge being neatly dressed with a fine rasp, followed by sand paper. The pillar, P P', is a round piece of pine 1¼ inches in diameter, 5 inches long, and provided at the upper extremity with two shoulders as shown. It enters a hole, *h*, in the center of the round top, T' T'', since definition will not be quite so good with the cheap lenses as with the better ones. Indeed, it must be admitted that an achromatic objective for the view telescope is most desirable. A cemented combination from an opera glass or small pocket telescope may often be had at a very moderate price from the repairers of such instruments, and, if substituted for the simple lens, will be found to greatly improve the seeing.

The telescope and collimator are carried in small supports, *cc'*, one of which is also shown in perspective at Fig. 3. These are constructed from short pieces of ½ inch pine the width of the body tubes, and have a semicircular niche fitting to the same cut out at one end. In these niches the bodies are held by bands of thin sheet brass, lapped round them, and secured by two small screws at each end fixed in the wooden part. In Fig. 3 a band of this sort, *bb*, is represented attached at one end by its screws and free at the other extremity ready to admit the tube round which it is to be clamped. The carrier, C', for the collimator tube should be 1¼ inches high to the bottom of the concave. To allow for the thickness of T' T', that for the view telescope must be ¼ inch higher. This latter is secured to the extremity of the arm, A, by a small wood screw, as figured, while the collimator support is similarly fixed close to the edge of the table, T''.

A small circular stage, *ss'*, of ¼ inch pine, 2½ inches in diameter, cut out with the compass saw and dressed smooth on the edge with sand paper, supports the prism. It is held in place and its level adjusted by three slender wood screws with half round heads, two of which are seen at K K' entering the table, T' T'. Between the stage, *ss'*, and the table, T' T' (which are of course placed concentric), we insert a section of a small soft cork, V, which by its elasticity keeps the stage quite firm, while readily admitting of necessary adjustments by means of the three stage screws.

A holder, Z, of ⅛ inch sheet brass, ¾ inch wide, formed as shown in Fig. 5, will be necessary to keep the prism steady upon the stage. It will require to stand 3 inches high, and the extremities bent at right angles in opposite directions will measure 1¼ inches and ½ inch respectively. This holder is fixed to the table by a round-headed wood screw passing through a hole in the lower bent extremity, the other being turned so as to press upon the cork stopper in the neck of the prism.

Plain directions for making simple slits appeared in No. 672, and will therefore not be repeated here. The non-adjustable form there described will fully answer every purpose for the present instrument; but two or three slits of different widths had better be prepared to suit various classes of experiments. It is quite possible to arrange over half the length of one of these slits what is termed a *prism of comparison*—a most useful adjunct, as it permits of two spectra being simultaneously shown in the field of view, one appearing above the other, whereby the coincidence of lines or bands is readily observed. In this case, such a comparison prism is made from a short piece cut from the smallest size of gasalier crystal drops; choice should be made of one having an angle of 90° or nearly that. A piece ¼ inch long, having been broken off by the aid of a file scratch or diamond cut on each face, the surfaces of cleavage are ground as truly flat as possible. The small prism thus formed is then secured upon the outside of the slit by acetic glue in the position shown at Fig. 4, where *p* is the swell prism, *s'' s'''* the brass slit jaws, affixed to their cork backing, *q q*, and *t' t'* the collimator draw tube. It will now be apparent that any luminous source placed in the direction L will send its rays into the slit by total reflection at the inclined internal surface of the glass, as indicated by the dotted line. This prism should occupy the lower half of the slit as at *p*, Fig. 2, the upper half

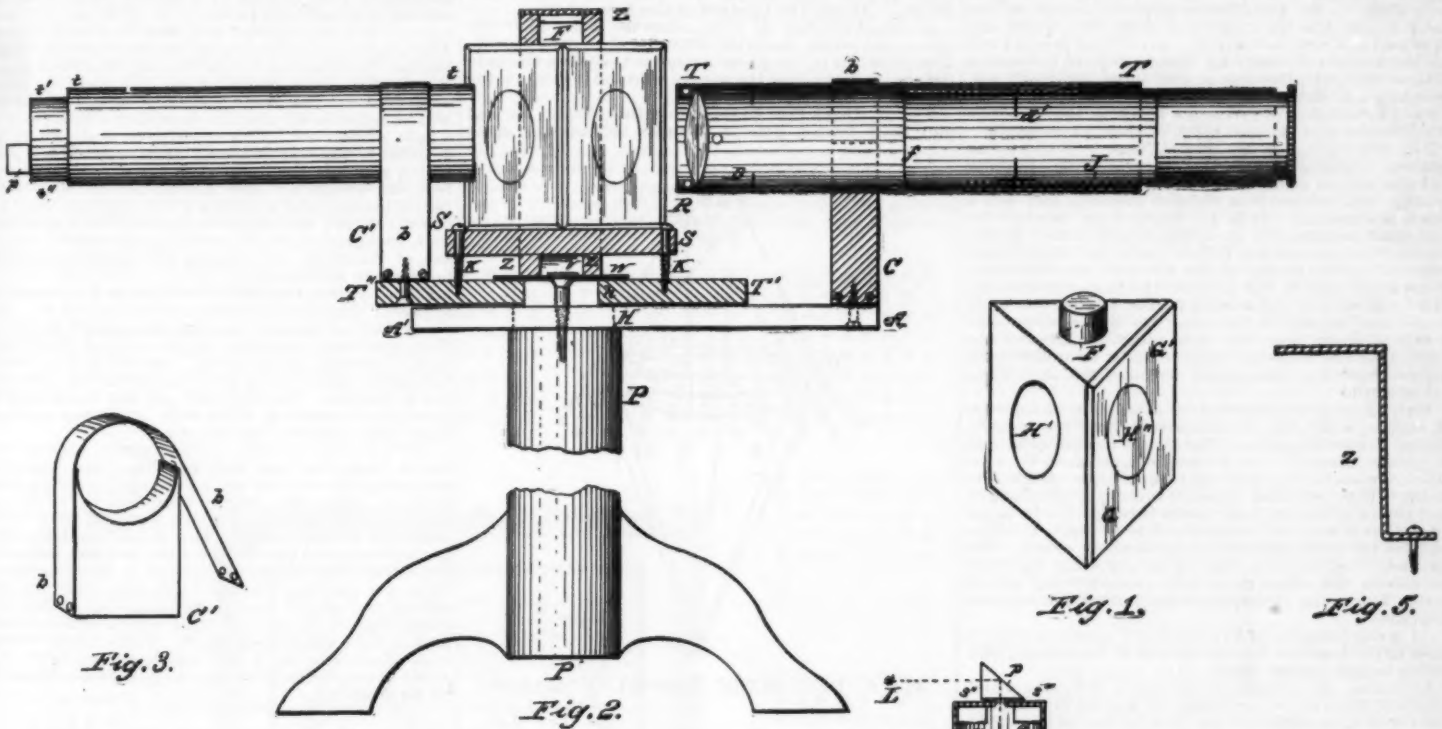


Fig. 1. Fig. 5. Fig. 3. Fig. 2. Fig. 4.

Spectroscope with Fluid Prism.

being left clear to receive the rays from a source of light placed directly in front. Good definition at the juncture of the two spectra juxtaposed in this way will depend on the care exercised in truly flattening and fine-grinding the upper triangular surface of the comparison prism.

As a support a tripod of the style depicted will be found steady, and it looks well. Of course a simple round wooden ball will answer the purpose. The finish of the instrument must depend on the taste of the maker. The table top and prism stage should be dull black, the pillar and foot may be stained and varnished to imitate mahogany, the brass tubes and bands should preferably be polished and lacquered, and the heads of the small screws blued in a spirit lamp flame.

The assembling of the various parts and their adjustment will be apparent to any one at all familiar with the theory of the spectroscope; or otherwise, reference should be made to the instructions in No. 651. The view telescope and collimator tube have, for the sake of clearness, been represented as though directed in the same line. Of course by moving the former round the pillar they will be placed at the proper angle to one another and to the faces of the prism. A black cloth should be employed to keep out stray light when the spectroscope is to be employed in sunshine or a brightly lighted apartment.

OPTICAL PHENOMENA OF THE ATMOSPHERE.

THIS is the title of a lecture recently delivered by Mr. A. Cornu, member of the French Institute and of the Bureau of Longitudes, before the French Association. The eminent physicist reviewed the optical phenomena that are found in our atmosphere—the blueness of the sky, the peculiar tone of twilight, which are so familiar to us that we do not observe them; also others, like the rainbow, the halo, and the mock sun, which are rarer and less easy to observe. Mr. Cornu pointed out the importance of studying these subjects, the causes of these natural phenomena, and more especially meteorology and the movements of the atmosphere. He showed by different experiments which we shall describe the different explanations given of these phenomena.

The Blue Color of the Sky.—There is evidently an intimate relation between the blueness of the heavens and the various colors of the sky at twilight. The air is only blue where it is lighted laterally and has a black background. It is for that reason that the distant shadows appear more or less a pure blue. In this respect the atmosphere differs from the blue limpid water of certain lakes. If the air were blue like these transparent waters, the greater the distance through which the rays of light would have to pass, the bluer would they appear, in the same way that a white shell in one of these lakes becomes bluer, the greater the depth may be. The sun, however, as it approaches the horizon becomes orange, and becomes red as it sinks out of sight.

Water may be represented by a solution of sulphate of copper, which has a transparent blue appearance, and all the peculiarities of the air are reproduced by an emulsion formed of a few drops of an alcoholic solution of resin of mastich and turpentine in distilled water. This emulsion appears blue in a lateral light, and yellow where the light passes through it. In larger quantities it becomes orange, and even red. The blue and the red of sun-set are complementary colors. The air, therefore, serves to decompose the white light and to reflect the blue rays and transmit the yellow rays. This is the principle of the various colors of the heavens.

As a confirmation of this we might mention the red glow of the heavens during the end of November, 1883, which lasted for two years.

Krakatoa, the volcano in the island of Sunda, which began to be in active eruption on August 27, 1883, and destroyed some 50,000 people during one of its explosions, threw an enormous column of dust and cinders many miles into the air. This light dust at this enormous height was carried by the air current in the course of a few weeks entirely around the earth, forming a veil, which was only detectable during the day by a whiteness that it gave the sky and a red ring around the sun. At sunset, however, this veil appeared like a cloud illuminated by the sun long after it had set. The light had been deprived of its blueness in its long journey, and appeared with that beautiful red glow so much admired at that period.

The Rainbow.—Every one loves to watch the birth of a rainbow, as it appears to emerge from behind a black cloud, upon which the rays of the sun are just beginning to play after the passing shower. Descartes first explained this phenomenon, illustrated in Fig. 3, which is taken from the *Traité des meteores*, published in 1637, after the publication of the celebrated *Discours sur la methode*. The theory was proved and rendered classical by the mathematical calculations of Newton. The ray of light strikes a drop of water (represented by the circle), is refracted, then is reflected from the interior wall of the drop, and then emerges therefrom, being refracted a second time. As the rays which make the white light are decomposed unequally, the greatest

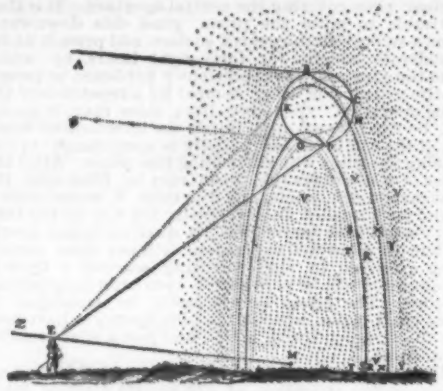


FIG. 3.—DESCARTES' THEORY OF THE RAINBOW.

illumination for all the colors of the spectrum does not occur at the same angle. Thus a colored bow is obtained concentric with the observer, having the red band on the outside and the blue and white bands within. This is the rainbow of the first order.

A second rainbow is often observed, paler than the other, but larger, and with the order of colors reversed. The principle of the phenomenon is the same, the only difference being that the ray is reflected twice on the interior of the drop of water.

Fig. 1 shows how to reproduce this effect. Rays of sun light from a hole in a screen fall upon a globe

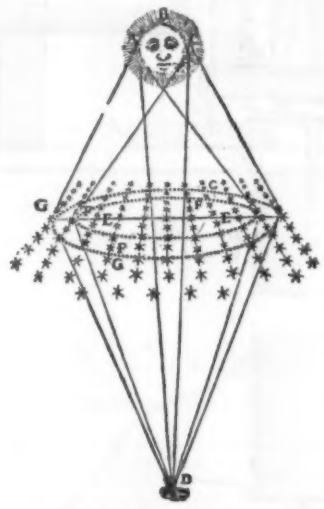


FIG. 4.—DESCARTES' THEORY OF HALOS.

filled with water. The luminous rays are reflected in the same manner as above described, and are divided into two arcs which are observed on a white screen placed a few yards away. The colors are less striking of course than in a natural rainbow, but the characteristics are all there, and the colors are in the same relation.

Rings.—If two plates of glass with lycopodium powder between them are interposed between you and the rays of light passing through the aperture as before, variegated rings are observed about the solar image similar to the rings about the sun and moon. Here the lycopodium grains of equal size replace the drops of equal size of which clouds are made which produce the rings. These belong to the same order of phenomena probably which produced the rings about the sun from 1883 to 1886, after the eruption of Krakatoa. The dust played the same part as the lycopodium.

HALOS AND MOCK SUNS.

We often observe large circles about the sun and moon. It is considered a sign of a change of weather, and in summer is generally considered as an indication of rain within forty-eight hours.

The phenomenon of the halo or mock sun is due to the refraction of rays of light from particles of ice floating in the atmosphere. The circular form of the halo is due to the fact that the ice prisms have various shapes and the refracted rays cannot suffer the slightest deviation from the true path. In the mock sun the reflecting particles are set in a vertical plane.

The credit for having first explained the halo is likewise due to Descartes, who, however, like his contemporaries, confounded it somewhat with the rings caused by diffraction from globules of water in the clouds. Fig. 4, which is also taken from *Traité des meteores*, shows the ice crystals as stars placed between the sun and the observer.

The more exact theory, however, of all these phenomena is due to Bravais. The ice crystals are for the most part crystallized in hexagonal forms. The angles of 60° which form the lateral faces of the crystals produce halos or mock suns of 22°. The refracting angles of 90° which form the lateral sides of the prism produce those of 46°. Brewster reproduced a halo by looking at the sun through a glass covered by alum crystals. But Brewster's experiment does not usually give an exact imitation of the phenomena. When an alum solution crystallizes on a plate of glass, it forms usually in octahedrons and parallel to the plate, and does not produce the variety of shapes necessary for a successful reproduction.

Owing to the importance of the subject, Mr. Cornu has experimented, and has found a way of making a successful reproduction of these phenomena. A solution of alum is saturated cold in diluted alcohol. The solution is then placed in a hollow glass vessel and alcohol is added, equivalent to 10 or 15 per 100, to the solution of alum and this is shaken for several minutes The gradual precipitation of the minute crystals then begins. They are soon seen floating about and glistening like the little blades of ice described by various observers. If the vessel is shaken, all the phenomena will be reproduced that are seen in the heavens when a halo is observed. This experiment is shown in Fig. 2. This is what takes place. First a sort of fog is seen which conceals the light when the crystals shaken up from the bottom are large and numerous; then the fog begins to clear, and a narrow circle appears, describing a circle of 22°, the inner border of which is red on a dark background, which extends to the center, but outside of the circle, as in nature, the background is blue fading into whiteness.

Little by little the colors brighten, and a second halo appears; this is a duplication of the halo of 46°. Both these rings increase in clearness to a certain degree and then gradually fade away as the crystals slowly settle to the bottom of the vessel. The effect is sufficiently distinct to permit of its being projected on a screen for use in lectures. To carry this out, the vessel should be placed in the path of light, thus producing an illuminated disk, representing the sun.

Parhelic Circles.—The curious circle or white tracks which cross the sun and appear either parallel or oblique to the horizon are reproduced in a very simple manner. The effect will be produced by looking at a light through a pane of glass that has been rubbed with wax by the fingers. This should be done in lines perpendicular to the direction selected for the parhelion. Stars and crosses are formed in the same manner. This may also be projected. The same effect, however, can be reproduced even more simply by placing small glass tubes in the path of light, which reflect the light and produce the desired effect. These recent researches of Mr. Cornu show how much science owes to the study of experimental meteorology.—*Gaston Tissandier in La Nature.*

GALILEO AND THE MICROSCOPE.

THE Italian scientist, Mr. Govi, has presented to the Academy of Sciences a report in which he wishes to prove that Galileo was the inventor of the microscope, as well as of the telescope. He takes as his evidence a book which was printed in 1610, and which he has just discovered. Shortly after this date, the philosopher himself stated that, by means of a lens, he had examined the motions and organs of minute animals. In a letter written by him to Signor Tarde in 1614, he said that with his microscope he had seen flies as large as sheep, the body covered with hairs and armed with pointed claws. The date generally assigned as that of the discovery of the microscope is 1621, and its invention is attributed to the Hollander Cornelius Drebbel: but, according to Mr. Govi, the merit of it belongs to Galileo, and the date of it must be put back eleven years.—*Gazette Geographique.*

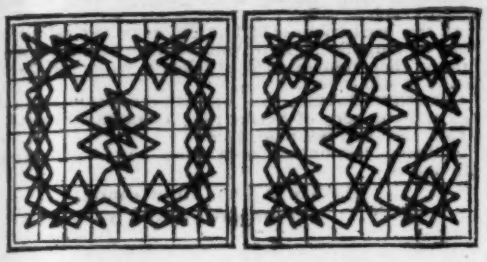
FIG. 1.—ARTIFICIAL FORMATION OF A RAINBOW.

FIG. 2.—ARTIFICIAL FORMATION OF A HALO.

THE "STURMER" CHESS BOARD AND MAGIC SQUARES.

Designed by EDWIN STURMER, C.E., Dunedin, N. Z.

IT is not universally known, even among chess players, that the knight can make a journey over the 64 squares of the board in as many moves; that the number of variations in the course that may be followed is, so to speak, infinite; and that the tour may be represented by geometrical figures, some of which are really elegant in design, when the course of the knight has been judiciously chosen.



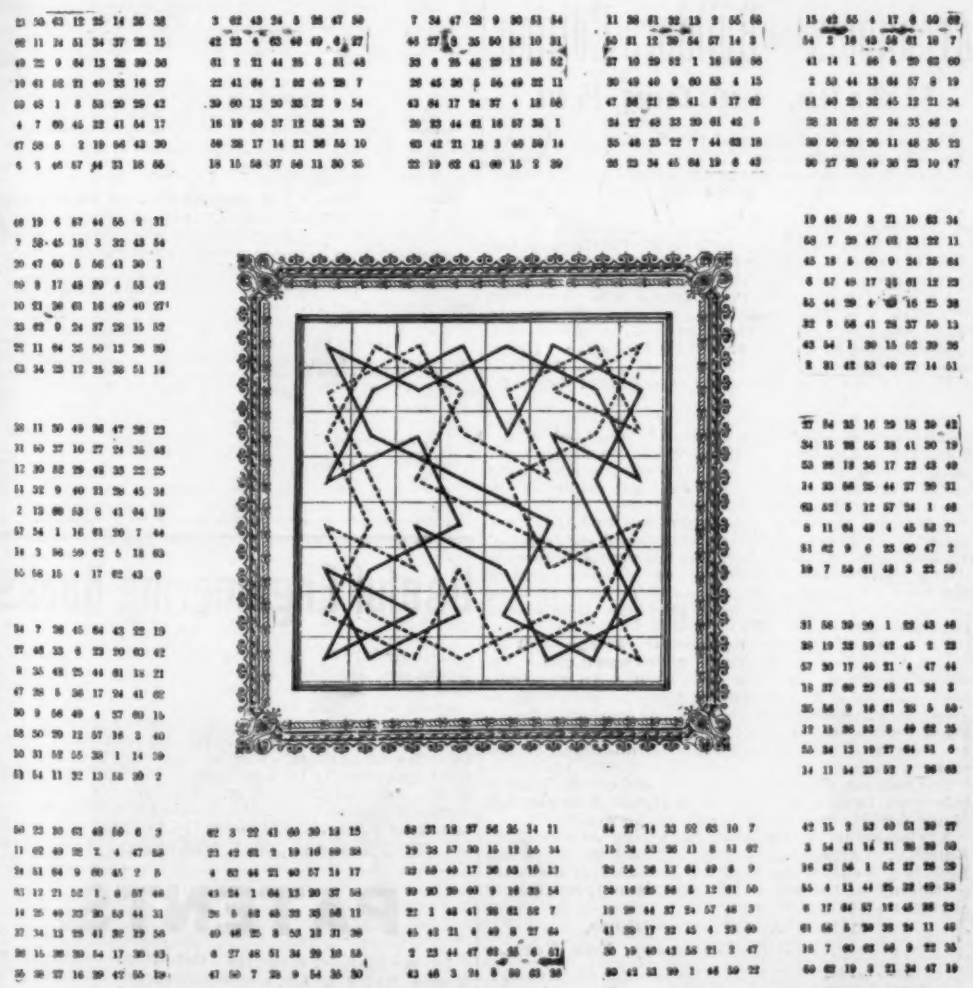
A critical examination of these designs will show that their symmetry is due to the circumstance that in describing the tour the knight alights at regular intervals, in the same order, on corresponding squares in the four quarters of the board (the board having been divided into four equal parts by vertical and horizontal lines drawn through its center); the 64 moves being constant and varying.

They may be arranged in groups showing corners identical and centers varying, or centers agreeing and corners varying, while not two designs are alike.

Eight different groupings of the numbers 1 to 64, each of which, while it represents a circular tour of the knight, gives at the same time a magic square; the total of the numbers in each vertical column or horizontal row amounting in every case to the constant number 260.

Out of over six hundred of the composer's designs, five alone give magic squares.

Each of these, out of sixty-four different groupings of the numbers 1 to 64 (which every symmetrical figure representing a variation of the knight's tour will admit of), gives only two different groupings which fulfill the condition of showing a common total of 260 for each group of numbers, vertical or horizontal, as the case may be.



NATURAL GAS IN LOUISVILLE, KY.

LOUISVILLE is soon to be supplied with natural gas from the great wells of Brandenburg, Meade Co., thirty miles distant. A pipe line is now in process of construction. Prof. Edward Orton, the geologist, says:

A few statements must be made as to the geological scale and structure of that portion of the Ohio Valley in which the new gas field is situated. The valley is bounded by massive cliffs, 200' to 300' in vertical thickness, belonging to the Keokuk and St. Louis divisions of the subcarboniferous limestone. In the valleys proper, the rocky floor is eroded to a depth of about 100' below the present low water stage of the river, the place of the eroded rock being taken by the usual line of valley deposits—clay, sand, gravel, and bowlders, variously intermingled. From the level of the bottom lands, the drive pipe in the new wells is quite uniformly from 100' to 125' in length. Below the drive pipe, a series of limestones, shales, and, possibly, shaly sandstones is struck, which continue for 100' to 300'; and this, in turn, is followed by about 100' of soft, blue shale, called soapstone, or sometimes "mud rock," by the driller. In the upper beds of this soapstone, the casing of the wells is usually set. The soapstone is, in turn, underlain by a bed of black shale, 50' to 100' in thickness, and this is the main gas rock and also the source of the salt water of this district.

Under the black shale, a series of solid limestones, 200' to 300' thick, occur, in which a peculiar brine, known as "Blue Lick Water," is often found. This sort of brine occurs in the limestones of various geological ages. Under the limestone there are 600' or more of interstratified shale and limestone, below which another solid bed of limestone is found, which continues, with few interruptions, for many hundred feet.

A recapitulation of the facts now given can be made in the accompanying statement:

St. Louis Limestone, } Cliffs of the Ohio Valley, but
Keokuk Limestone, } continuing below the surface.
Knobstone Group—Mud rock or soapstone of the Meade County driller, in part.
Ohio Shale—New Albany shale—Meade County gas rock.
Louisville Limestones—Devonian and Upper Silurian.
Hudson River Group.
Trenton Limestone.

The Meade County gas horizon is not like the Findlay gas rock, a new comer in the field. The Ohio shale, under its various names, has been as long and as well known in connection with natural gas as any other stratum in our entire series. Along its outcrops in Western New York, on the shores of Lake Erie, the gas springs that issue from it have been known since the region was first occupied by civilized men. The utilization of the gas in this region goes back, in fact, to the first quarter of the present century. The gas springs of Fredonia, Chautauqua County, New York, were brought into use, for lighting the town, as early as 1829. The attention of Lafayette, on the occasion of his second visit to the country, was attracted to this remarkable phenomenon. The town is still making use of the same wells. A few years later, the government lighthouse at Portland Harbor, near Westfield, in the same county, was lighted by natural gas derived from the same shales, and the supply was continued until the harbor was abandoned. Since these earlier examples of successful use, wells have been drilled by the hundred, along the lake shore and in contiguous territory, expressly in the search for gas for household use. There is scarcely a mile, and certainly not a single township, along the line of the outcrop of this formation, from Silver Creek in New York to Huron River in Ohio, in which wells have not been drilled for gas. In many towns and villages, a large and conspicuous service has been rendered by these wells. Erie, Pa., and, in Ohio, Conneaut, Ashtabula, Painesville, and Cleveland, may all be named as examples of this successful use. Throughout the entire district, success in drilling these wells has been the rule, and failure the comparatively rare exception.

After this wide and long-continued experience in the gas production of the Ohio shale, the geologist certainly felt warranted in deducing the laws and characteristics of this production. The characteristics are easy to define. The gas is of the Pennsylvania type, free from the sulphurous compounds of limestone gas; it is low-pressure gas, or, in other words, it is not reservoir gas; it is not closely associated in production with salt water in the rocks. The shale sometimes contains salt water, it is true, but the gas is not delivered by the pressure of a water column. Such pressure is presumably the cause of the flow of high-pressure or reservoir gas. The shale is practically an impervious rock. The pressure of the shale gas never exceeds 100 pounds to the square inch, and is generally limited to from ten to thirty pounds to the square inch—the daily yield of shale gas wells is consequently small. A production of 100,000' per day is unusual. The wells already described are mainly limited to less than 10,000', or to even less than 5,000' per day. This small production, and the absence of an aggressive water column in the rock from which the gas is drawn, give to these wells their long lives. Deductions drawn from these low-pressure wells are not applicable, unmodified, to high-pressure wells. The former may last for centuries, where the latter would exhaust themselves in decades, or even in a single year. . . .

The gas of the shale wells appears to be indigenous; that is, it is derived from the rock in which it is generated. The supply may be maintained by a slow conversion of the oil with which the shales are charged into gas. But there is nothing to indicate that the total amount of petroliferous contents in the shales has been increased since they were originally deposited.

These conclusions in regard to shale gas production seemed, as before stated, to be established on a sure foundation, and the geologist might well feel warranted in predicting what the behavior of the formation as a gas rock would be, in any new locality in which it should occur.

The Meade County gas is unmistakably derived from the black shale, and it agrees with such an origin in chemical composition. But all of the other more important conclusions that we have drawn in regard to the characteristics of shale gas are promptly set aside by the new experience. The Meade County gas is reservoir or high-pressure gas. It is associated with, and driven by, a salt water column. Its wells reach a maximum production of 2,000,000' per day. They are greatly improved by the use of torpedoes. The rock pressure is low, it is true; but this evidently results from the shallow depths to which the gas rock is found, for the depth is always a function of the rock pressure in reservoir wells. In the heart of the new field, the rock pressure ranges from 100 to 125 pounds per square inch, the depth of the wells ranging from 300' to 500' below the surface. Again, the gas wells of this district produce salt water freely in connection with the gas, without in all cases, at least, being overrun by it.

All this is confusing to a high degree. It seems, at first sight, as if such an experience destroyed all possibilities of scientific or practical prevision in the search which our cities and towns are so eagerly pressing. But a closer examination shows us that but a single change has occurred in the character of the shale. Through the accidents of its history, it has become a porous rock, and, consequently, a reservoir for gas, oil, and salt water. All the other changes, above noted, follow at once, upon the transformation of the shale from an approximately impervious rock to a porous rock. . . .

The statements given above suffice to show that the black shale, when dipping from its outcrop, at New Albany, to a depth of 300' to 500' in the Ohio Valley, becomes, under certain conditions, a reservoir of natural gas and salt water on a large scale.

THE LOSS OF NITROGEN CAUSED BY WORKING AND AERATING THE SOIL.

ALL cultivated land appears to inclose germs of the nitric ferment, whose action has been so well studied by our learned agriculturists Muntz, Schloesing, and Deherain, from whom we borrow these remarks. The activity of this ferment varies with the temperature, with the moisture, and with the concentration of the ammoniacal solutions upon which it acts. Since this ferment is aerolic, *i. e.*, lives at the expense of oxygen, it might readily be imagined that it would produce a greater effect in a soil opened by the action of the plow than on one left untouched, and that therefore tilling and dressing the land would favor nitrification.

A more complete aeration of the soil is, however, not the only effect produced by working the soil. M. Schloesing has observed that if well aerated earth be placed in a bottle, only small quantities of nitrates are produced, while the amount is largely increased by triturating the whole in a mortar. The effect of this is obviously to disseminate the ferment and bring it into contact with new alimentary materials. It is well to notice that things do not go on within the soil in the same way as in the solutions used for cultivating ferments; there is no sheet of water in the earth which allows the ferment to propagate itself; it remains wherever it happens to be, and when it has exhausted the stock of organic materials with which it is in contact, it probably forms spores, which wait for favorable conditions to enable them to develop and set up their characteristic action.

The plowing of a field helps to mix the soil; the ferment is consequently disseminated, and its activity is then immediately betrayed by an increased production of nitrates. In a soil permeable by air and hard water, the nitrifying power is largely increased—not merely enough nitrates are made to serve for the support of the plants present, but a certain portion drains into the subsoil and is thence removed by the drain water. Nitrification is, moreover, not only produced by the aid of ammoniacal salts, but also by that of the nitrogenous materials of manure, of oilcake, etc. In this case the combustion of the nitrogen can only take place at the expense of an equivalent amount of carbon, and the increased nitrification, therefore, tends to deprive the soil of its organic matter, which is itself of the greatest value, inasmuch as it retains moisture, and thus enables the plants to withstand two seasons of continued drought without withering. A soil which is thus opened every year and subject to numerous and repeated dressings becomes fatally impoverished in organic matter. We have often drawn attention to this point, that along with the dressing of the soil the use of manure or some organic matter or other is indis

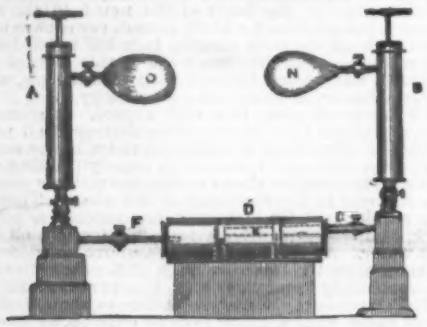
pensable, and that the results obtained by the use of chemical fertilizers will be in direct proportion to the amount of organic matter with which these fertilizers have been associated.—*L'Engrais.*

SEPARATION OF OXYGEN FROM THE ATMOSPHERE.

By H. N. WARREN.

THE diffusion or osmotic properties of a gas, when compared with another of opposed density, have been pointed out from an early date, perhaps one of the simplest means of observing the same being the swift passage of hydrogen gas when in admixture with one of greater density, through the pores of a moist membrane. So perfect, however, is this peculiar separation in the case of hydrogen when in admixture with an equal bulk of oxygen, the operation being performed in a caoutchouc bag kept weighted, that on examining the same after an hour's duration a sufficiency of hydrogen will be observed to have escaped, so as to totally destroy the explosive nature of the mixture.

By taking advantage of the peculiarity of caoutchouc to condense gases upon its surface, an apparatus has been lately constructed, and intended for the parting or partial separation of oxygen gas from the atmosphere as explained by the accompanying figure. It is composed of two somewhat powerfully exhausting syringes, A and B, the top extremity of each being provided with a cock, and connected to the same two small gas bags, the bottom or further extremity of each syringe being connected with a porous pot, D, provided internally with two disks of compressed charcoal, and charged with a preparation of finely divided caoutchouc, obtained by immersing the same, before using, in a solution of caoutchouc in naphtha. The outer wall of the porous cylinder is also provided with a tightly fitting jacket of very thin rubber, the pipe, E, in connection with the cork, C, being pierced with two small orifices, and terminating at the commencement of the second disk, and intended to remove the nitrogenous atmosphere remaining in the cylinder after the separation of the oxygen by means of the syringe, A. The piston rod of the syringe, A, being now raised upward, a vacuum is naturally produced within the porous cylinder, D, and being surrounded by the atmosphere, an inward pressure is at once experienced, the result being that the cylinder is partially filled with an atmosphere extremely rich in oxygen, and also with one in which nitrogen predominated largely, which, by



working the piston on either side of the cylinder with due care, may be collected in their respective bags, namely, O and N, intended for the reception of the same. On submitting both portions of these separated gases to examination, that portion obtained from the syringe, A, was found to be sufficiently rich in oxygen to readily rekindle a glowing splint, and even support the combustion of iron wire, results of several analyses proving an existence of 50 per cent. of oxygen, while the nitrogenous atmosphere collected by the opposite cylinder readily extinguished a lighted match when introduced into the same. By a slight alteration in the arrangement of the apparatus a mixture of hydrogen and oxygen was separated so effectively as to produce only the minutest quantity of water when separately made to ignite. Carbonic anhydride and various other gases in admixture with one another were experimented upon with a like result.—*Chemical News.*

NICKEL AND COBALT.

DR. KRUSS, of Munich, has recently reported that, from his examination of the behavior of the salts of nickel and cobalt, he has been able to demonstrate that neither of these bodies are elementary substances. The atomic weights of nickel and cobalt are, as is well known, almost identical, and Dr. Kruss considered that a redetermination of these contants might throw some light on the very close relationship which exists between these two bodies. Dr. Kruss has been engaged on a long and laborious investigation on the atomic weight of gold, and the important work which he has published on this subject has shown that his careful methods of procedure, and accurate work, could not be better employed than in an investigation such as the one he has undertaken.

The method suggested by Winkler for attacking this problem is based on the decomposition of gold chloride by nickel and cobalt, and thus the previous work of Dr. Kruss rendered him particularly suited for undertaking the investigation. He found that the gold separated in the reaction contained some substance which gave a green color in acid solutions, and a white precipitate on the addition of alkalies. By fusing oxide of nickel or cobalt with potash, and treating the melted mass with water, Dr. Kruss has obtained a solution which contained some of this hitherto unknown material, while the pure oxide of nickel or cobalt remains undissolved. The oxide of the common element present in nickel and cobalt oxides is of a white color, and readily soluble in hydrochloric acid. It can be reduced by charcoal to a brown metallic powder, and ammonium sulphide precipitates from its solutions a brown sulphide. It also appears that a small quantity of the chloride of this substance added to a solution of cobalt chloride changes its color from red to green, and the author is therefore of opinion that what has hitherto been considered nickel in solution is a mixture of the salts of cobalt and this new element. The quantity of the new substance at present isolated has been so small that a further description of its properties and a determination of its atomic weight are postponed until the author is able to obtain larger quantities of the oxide.

At the last meeting of the Chemical Society, in London, Dr. W. J. Russell, F.R.S., gave a resume of the work which he has recently been engaged upon, and which contributes to the discussion on the constitution of these two elements. Dr. Russell has been studying the absorption spectra of solutions of the chlorides of nickel, cobalt, and iron, and has found that when the solutions are very concentrated and saturated with hydrochloric acid a very marked resemblance between the absorption spectra of iron and cobalt chlorides is noticed. The concentration of the solution appears to determine the breaking up of the general absorption, and bands of absorption make their appearance. Several of the bands characteristic of the cobalt chloride solution coincide in position with those obtained with a solution of ferric chloride, and this coincidence led the author to examine various samples of iron from different sources, in order to determine whether cobalt might not be present in some of the usual iron ores. He has found, however, that the spectra is given by all the samples that he has examined, and consequently his experiments indicate that iron and cobalt are, therefore, very nearly related. It may be that further investigation will show that iron contains the same element as the experiments of Kruss go far to prove is common to both nickel and cobalt. All three of these elements have atomic weights which are very close to one another, and their general chemical behavior is such as to tend to support such a hypothesis. It is well known that Prof. Crookes has on several occasions advanced views which give a complex nature to what have hitherto been supposed to be elementary atoms, and the periodic law has afforded little explanation of the closeness of the atomic weights of the elements which appear in the eighth group, to which these three elements belong.

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